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SOME ORTHOPAEDIC PROBLEMS OF THE LOWER JAW, WITH SPECIAL REFERENCE TO UNILATERAL SHORTENING*

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Functional disabilities of the mandible and its attachments have not received the same amount of attention from orthopaedic surgeons as those of other bones and joints. Yet disability and deformity from injury or disease may be just as marked here as elsewhere in the body, and in addition there are cosmetic features which demand consideration. It is true that ankylosis of the mandibular joint has been the subject of extensive study by such eminent orthopaedic surgeons as Baer, Albee, and others. We do not intend to discuss ankylosis at this time, except to mention that in its treatment attention has been directed almost entirely to mobilization of the bone, without regard to the almost equally important restoration of prominence of the chin and correction of malocclusion of the teeth. The consideration of contour, as well as function, in operations for organic ankylosis of the lower jaw is fully dealt with by Blair in a recent article[1].

Functional disability and visible deformity very similar to that resulting from ankylosis, but in which the mobility of the joint is not disturbed, may follow certain injuries and diseases in early life. In all of these cases, there is a shortening or an actual absence of bone on one side of the mandible. There may or may not be loss of bony continuity. The unilateral shortening produces a deviation of the chin to the affected side; the chin in profile is retruded. The lower front teeth are markedly posterior to the upper and may bite against the roof of the mouth. The teeth of the normal side of the lower jaw also deviate toward the affected side. The affected

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side of the face has a rounded appearance while the normal side is somewhat flattened, just as in ankylosis. In case of loss of continuity, there is added a marked instability of the mandible, increasing the difficulty of mastication.

Probably the commonest cause of this deformity is osteomyelitis and necrosis of the lower jaw, due to dental infection in early childhood. We have also seen it follow injury to the ascending ramus in forceps delivery, fracture of the neck of the condyle in a child, and an operative defect in the bone from removal of a tumor. It has been the writers' observation that while fracture through the neck of the condyle may result in unilateral shortening, this is seldom accompanied by ankylosis. To have ankylosis, there must be an injury to the head of the bone and the glenoid fossa.

This unilateral deformity can many times be prevented by appropriate measures, taken at the time of the original disease or injury, to maintain the proper relationship of the upper and lower jaws by wires or splints fixed to the teeth. Thus, in cases of osteomyelitis of the posterior part of the mandible, where sequestration involving a loss of continuity ensues, it is frequently possible to hold the normal occlusion of the remaining teeth by simple wire ligatures passed around them, or by more elaborate appliances. If spontaneous bone regeneration occurs, the jaw will then have its normal length, and if a gap remains in the bone, the remaining portions will have been maintained in proper position to simplify future restoration by bone grafting. Where this preliminary maintenance of position is neglected, the parts collapse, and we have the deformity, with or without union.

Correction of unilateral deformity of the mandible resulting from injury or disease in childhood has been dealt with by Kazanjian[2], Limberg, of Leningrad[3], Bruhn, of Dusseldorf[4], and others. All are agreed that the first step is to section bone or soft tissue adhesions at a suitable point along the short side to permit bringing the chin forward and to the midline. Several methods of restoring bony continuity with proper length have been suggested. Kazanjian favors a diagonal section, made intra-orally, through the short side of the mandible with a saw. This permits overlapping of the cut ends when the chin fragment is drawn forward, frequently resulting in spontaneous union after a period of interdental splinting in the corrected position, without bone grafting. However, this method is not applicable when there is an ununited defect. Limberg advises section with advancement of the chin, followed by a two-stage bone-graft operation. The first stage consists in embedding a suitably shaped piece of rib in the submaxillary soft tissues immediately beneath the gap in the mandible. After a period of several weeks, the bone graft, which by this time has a good blood supply from the soft tissues in which it is embedded, is freed sufficiently to permit its being brought up to fill in the mandibular defect. The object of this preliminary implantation of the bone graft in the soft tissues adjacent to the defect is to increase the chances of its survival, but we feel that this unnecessarily prolongs the treatment of the case.

The following procedures are recommended in cases of this type:

(1) *Unilateral Shortening of the Mandible When Bone Continuity is Present.*

Preliminary preparation. It is always advisable first to take impressions of the upper and lower teeth and prepare plaster-of-Paris models. With these models, the amount of correction of the occlusion of the teeth that may be obtained by operation can be worked out in advance. Sometimes it can be determined that a simple osteotomy will permit an almost normal occlusion. In other cases the osteotomy will only allow the bringing forward of the chin, and satisfactory dental occlusion will only be obtained by additional orthodontic means, or even by artificial substitution after extraction of teeth. Before any operative procedure is undertaken, provision must be made for fixation of the mandible in the corrected position. The appliance to be used will depend upon the condition of the teeth and the facilities at hand. Whatever apparatus is used, it should be applied separately to the upper and lower teeth before operation and provision made so that the two parts can be fixed together in the corrected position immediately after the operation.

First operation. After these preliminary preparations the first operation is performed. This consists of osteotomy at some suitable point along the horizontal portion of the short side of the mandible, preferably where a tooth is absent. If all teeth are present, which is rare in these cases, the section may be made at the angle of the jaw behind the last existing tooth. At all events tooth roots should not be injured in the section and allowed to remain, as this will interfere with healing. The osteotomy is made in the following manner (Fig. 1): A small skin incision, not more than one-half inch long, is made to the lower border of the mandible at the point where section is to be made. A curved antrum trocar with cannula is introduced through the incision close to the bone on the lingual side until

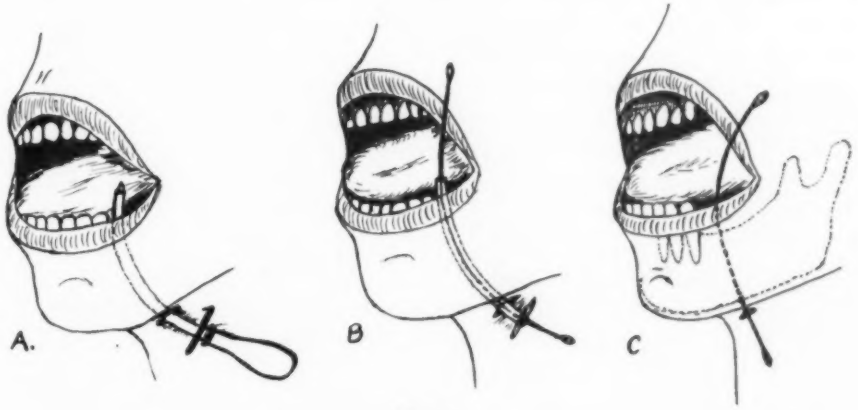

FIG. 1

OSTEOTOMY OF MANDIBLE. *A.* Trocar and cannula passed up into mouth on inner side of bone. *B.* Gigli saw introduced through cannula. *C.* Cannula withdrawn and Gigli saw ready for osteotomy.

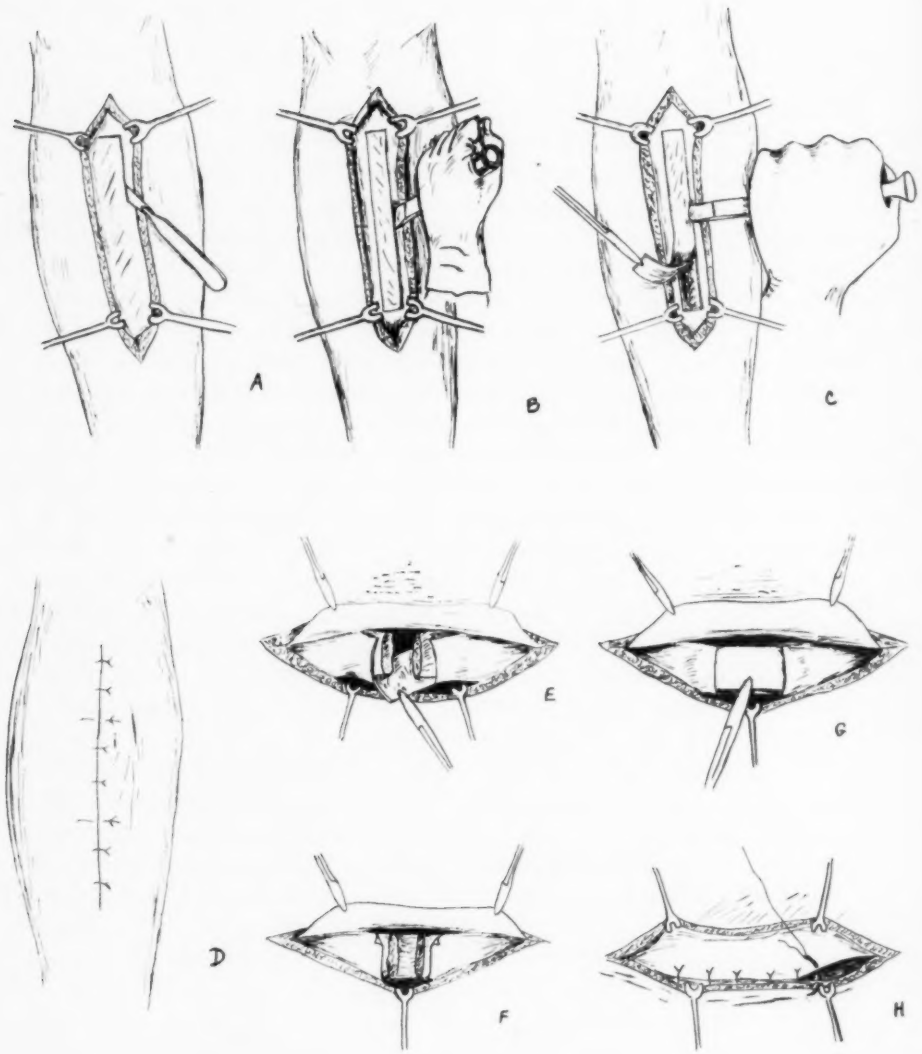

FIG. 2

OSTEOPERIOSTEAL GRAFT FROM TIBIA. *A*. Periosteum over antero-internal surface of tibia exposed and outline of graft traced in periosteum with knife. *B*. Graft outlined with chisel which penetrates bone to depth of about one centimeter. *C*. Osteoperiosteal graft removed with chisel held almost parallel to surface of bone. *D*. Leg incision closed. *E*. Piece of osteoperiosteal graft inserted in pocket beneath mandibular fragments. *F*. Deep piece of graft in place. *G*. Second piece of graft placed in pocket over mandibular fragments. *H*. Suture of deeper layer of soft tissues over site of grafts. *J*. Closure of skin incision.

the mucous membrane of the mouth is pierced. The trocar is then withdrawn, and a Gigli saw is passed through the cannula until one end protrudes into the mouth. After removal of the cannula, the mandible can be readily sectioned with the Gigli saw. The skin incision is closed with a fine dermal suture, without drainage, and usually heals by first intention, leaving practically no visible scar. It now becomes possible to bring the chin forward and to the median line, where it is fixed by connecting the appliances on the upper and lower teeth.

Waiting period. It is then necessary to wait for a period ranging from six to twelve weeks for the wound in the mouth to heal and for the bone ends to become surrounded with well seasoned scar tissue. In young children, with only a small gap produced in the bone in carrying the chin fragment forward, this gap may be filled in twelve weeks by spontaneous bone regeneration.

Second operation. In the majority of cases, a second operation to restore the continuity of the mandible by bone grafting will be necessary. Of all the methods of bone grafting, only two deserve consideration for restoring gaps in the lower jaw. One is the thin osteoperiosteal graft from the tibia (Delagénière), and the other the thick graft from the crest of the ilium, both of which have been described in an article by Ivy and Epes[5]. The osteoperiosteal graft is preferred for defects of two centimeters or less, and in cases where the external contour of the face shows little or no deficiency. The osteoperiosteal graft contains all of the elements necessary for osteogenesis, and the technique of removal and insertion is simpler than that of any of the other methods.

Technique of osteoperiosteal method. The procedure is divided into three stages (Fig. 2): *A*. Preparation of the mandibular site. *B*. Removal of the graft. *C*. Application of the graft to the mandibular defect. *A*. A skin incision with convexity downward is made over the region of the bony defect. The skin flap is turned upward. The scar tissue is removed to expose thoroughly the ends of the bone fragments. Extreme care is necessary to avoid opening into the buccal cavity. A pocket is prepared around the end of each fragment by stripping away the periosteum and soft tissues from the bone for a distance of about one centimeter. The exposed bone is thoroughly freshened by trimming with rongeur forceps. Bleeding is controlled as completely as possible. *B*. The antero-internal surface of the tibia is exposed by a longitudinal incision through the skin down to the periosteum. The graft to be removed, usually about ten centimeters long by two centimeters wide, is next outlined with the knife through the periosteum to the bone. With a broad, thin chisel, held perpendicular to the bone, the tracing made with the knife is accentuated, the blade of the chisel penetrating the bone to a depth of one to two millimeters. The chisel is then held almost horizontally, with bevel toward the bone, and a thin shaving of bone with overlying periosteum, included within the outline traced, is removed. This graft is cut into two or three pieces, as desired. The skin wound in the leg is sutured with silkworm gut. *C*. One

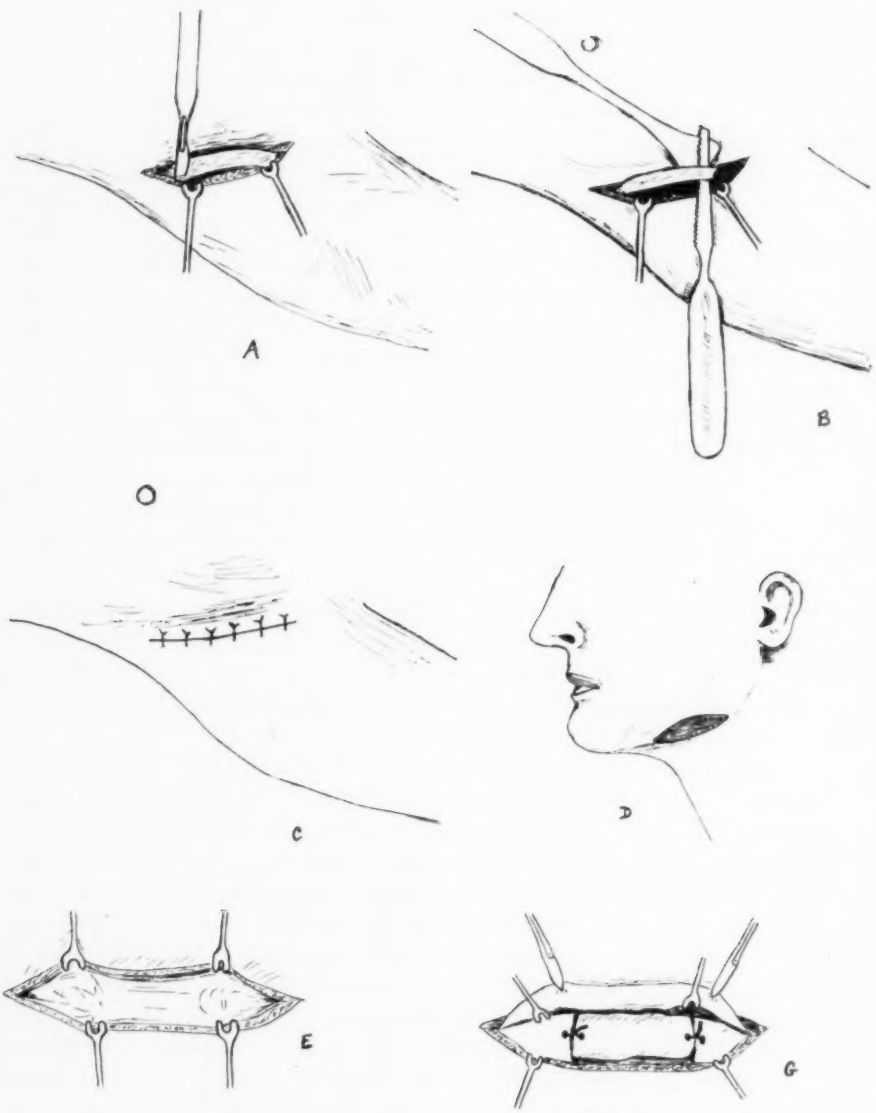

FIG. 3

GRAFT FROM CREST OF ILIUM. *A*. Crest of ilium exposed and muscles detached. *B*. Graft removed with saw, beginning at anterior superior spine. *C*. Skin incision closed. *D*. Skin incision over mandibular defect. *E*. Deep tissues overlying bone defect exposed. *F*. Ends of mandibular fragments exposed and wires passed through holes drilled in the bone. *G*. Iliac graft placed in mandibular defect. Wound closed in two layers as in osteoperiosteal graft.

piece of graft is inserted with its ends in the subperiosteal pockets on the inner aspect of the mandibular fragments. Another piece is inserted on the outer aspect of the fragments, the bony surfaces of the grafts facing each other across the gap. It is necessary that the grafts be in contact with the previously freshened bone ends. If desired, a third piece of graft can be placed along the lower border of the fragments. No direct fixation is used beyond suturing the deep tissues over the grafts and ends of the bone. The skin wound is closed with dermal sutures, usually without drainage.

Iliac graft. If the gap in the bone exceeds two centimeters and especially if the external contour is deficient, it is preferable to use a thick graft from the crest of the ilium. The crest of the ilium furnishes a large piece of bone, of porous structure closely allied to that of the mandible, is easily penetrated by new vascular supply, and can be readily cut to suitable shape. The disability produced by removal of the graft is quite temporary and the danger negligible. These points favor it over the usual thick graft from the tibia, which is dense, not easily penetrated by new vascular supply, is brittle, and hard to trim to the desired shape, and its removal may be followed by fracture of the leg unless extreme postoperative care is used. In these defects of the lower jaw, there is no necessity for strength and rigidity of the graft itself, because the fragments are already held firmly by dental splints and there need be no dependence upon the graft for immobilization.

The *technique* of grafting the mandible from the crest of the ilium is also divided into three stages (Fig. 3): *A*. The skin incision over the mandibular defect is the same as for the osteoperiosteal graft. A second layer of deeper tissues is then raised to expose the bone. Scar tissue between the fragments is carefully removed, and the ends of the bone are thoroughly exposed and beveled slightly to create broad freshened surfaces. A hole is drilled in the end of each fragment for the passage of a twenty-four-gauge brass wire. Bleeding is arrested. The length of the gap is measured with a probe. *B*. An incision is made along the crest of the ilium down to the periosteum, beginning at the anterior superior spine, back as far as necessary. The muscles attached to the outer and inner lips of the crest are stripped down, and a piece of bone is removed with a metacarpal saw, beginning at the anterior superior spine and working backward. The graft comprises the full width of the crest of the ilium and should be of sufficient length and depth to fill the gap in the mandible, allowance being made for slightly overlapping the mandibular fragments at each end. The detached muscles are brought over the site of removal of the graft and sutured together with chromicized catgut, and the skin of the ilium wound is closed with dermal sutures. A small rubber tissue drain may be inserted for twenty-four hours. *C*. Any fragments of muscle are removed from the graft, but periosteum is allowed to remain. The ends are slightly beveled and holes drilled in them. The wires attached to the mandibular fragments are then passed through the holes and twisted so that the graft

fits snugly in contact with the mandibular fragments. We prefer wire bone sutures to catgut or kangaroo tendon, because a very much firmer contact between the bones can be obtained. The ends of the wires are cut off short and turned over so that they will not project into the soft tissues. These wires usually remain permanently without causing irritation, but they can easily be removed later if desired. The layer of deeper soft tissues is sutured with catgut to cover the bone, and the skin flap closed with interrupted dermal sutures, usually without drainage.

Postoperative treatment. The splints or wire fixation on the teeth are kept in place for about twelve weeks after the graft operation. After eight weeks of complete fixation, the upper and lower jaws can be unlocked at intervals to permit gentle exercise and to stimulate bone consolidation.

Any remaining asymmetry or lack of prominence of the chin can then be corrected by implantation of costal cartilage on the anterior aspect of the bone. Malocclusion of the teeth can be overcome by appropriate orthodontic or prosthetic measures.

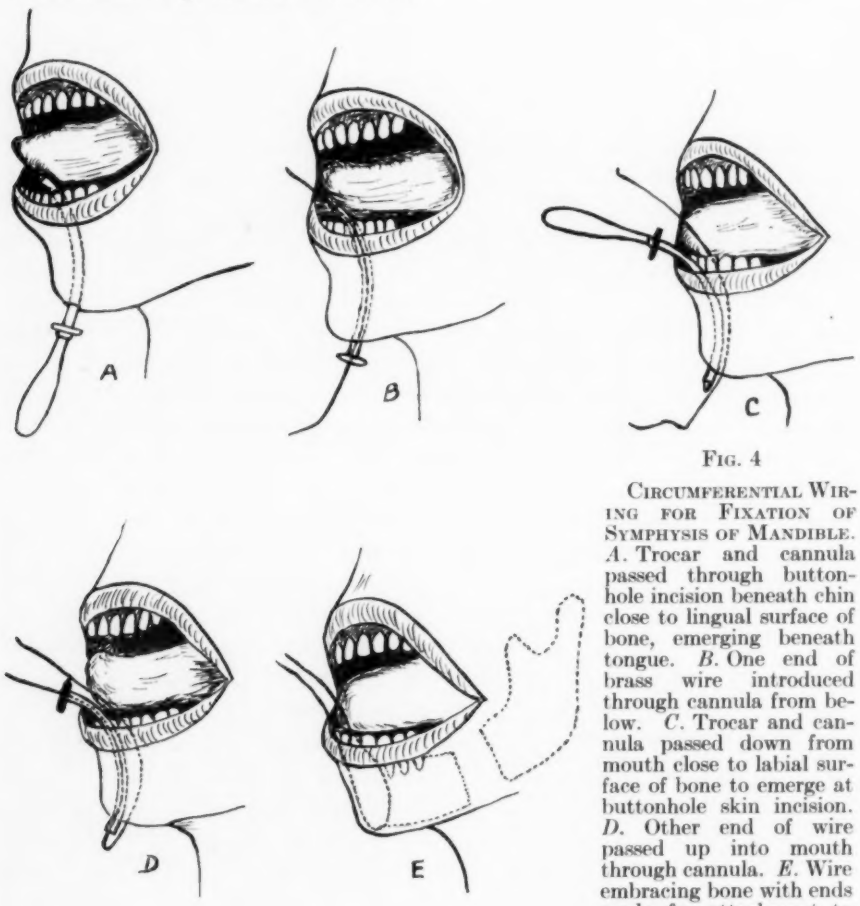

FIG. 4

CIRCUMFERENTIAL WIRING FOR FIXATION OF SYMPHYSIS OF MANDIBLE. *A*. Trocar and cannula passed through buttonhole incision beneath chin close to lingual surface of bone, emerging beneath tongue. *B*. One end of brass wire introduced through cannula from below. *C*. Trocar and cannula passed down from mouth close to labial surface of bone to emerge at buttonhole skin incision. *D*. Other end of wire passed up into mouth through cannula. *E*. Wire embracing bone with ends ready for attachment to upper teeth.

(2) *Unilateral Shortening Where There is a Pathological Fracture with Loss of Substance.* Here the main fragment, including the chin, is drawn over and bound to the short fragment by a band of scar tissue. There may be considerable freedom of movement between the two fragments. Sometimes it is possible by manipulation to reduce the chin fragment to a satisfactory position in relation to the upper jaw, but in doing this the short fragment is dragged over out of position. Consequently, the first operation here consists, not in osteotomy, but in thorough liberation of the fragments by division of scar tissue between them, until the two parts of the jaw can be retained freely in their normal positions without tension. This liberation can sometimes be done from within the mouth alone, but frequently a skin incision is also necessary. The procedure afterwards is the same as that following osteotomy,—namely, fixation of the mandible in proper relationship by interdental appliances until thorough healing from the first operation, and then filling the gap with a bone graft.

FIG. 5-A

FIG. 5-B

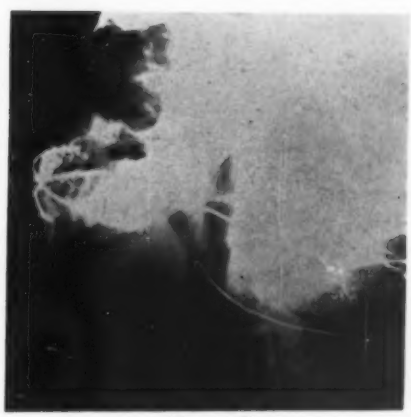

FIG. 5-C

FIG. 5

Darcissac's method of controlling edentulous posterior fragment of mandible. *A.* Wire sutured to angle of mandible emerging to pass around back of neck. *B.* Wires from angles of mandible connected around back of neck by elastic band, producing outward and backward traction on edentulous fragment. *C.* Radiograph showing wires attached to angles of mandible.

Methods of fixation. It is desirable to employ the simplest means available, so as not to be dependent upon dental laboratory aids. In the great majority of cases the teeth are sufficiently numerous, strong, and retentive to afford attachment to ligature wires and arches, whereby the upper and lower teeth may be fastened together. Where these means are possible the laborious and time-consuming laboratory work entailed in the manufacture of special splints for the individual case is avoided. Usually, the loop wire attachments as described by the writers[6] and others can be employed by the surgeon himself. Occasionally, especially in children, the teeth do not afford sufficient retention for the wires, and here

FIG. 6-A

FIG. 6-B

FIG. 6-C

FIG. 6-D

FIG. 6

Unilateral shortening of mandible, left side, with non-union, resulting from osteomyelitis. *A*. Profile before treatment, showing retrusion of chin as compared with prominence of upper jaw. *B*. Front view before treatment, showing deviation of chin to affected side. *C*. Radiograph of shortened left side, showing defect. *D*. Radiograph after osteotomy and forward fixation of chin with circumferential wire. Defect increased. *E*. Radiograph after filling of defect with osteoperiosteal graft from tibia. *F*. Profile after treatment. *G*. Front view after treatment.

FIG. 6-E

FIG. 6-F

FIG. 6-G

the aid of the dental prosthetist is enlisted for the preparation of suitable cast metal splints cemented separately to the upper and lower teeth and provided with lock-pins for fastening the jaws in occlusion after the operative reduction. Very efficient cooperation in this respect has been given by Dr. E. F. Axt, of the prosthetic department of the Evans Dental Institute. A useful adjuvant to the wires or splints on the teeth, for maintaining the chin in a forward position, is *circumferential bone wiring*, as first employed by G. V. Black many years ago[7]. This is usually done, when necessary, at the time of the osteotomy operation. For introduction of the wire (Fig. 4), a small incision is made through the skin just beneath the chin, and a curved trocar and cannula are passed through the incision close to

FIG. 7-A

FIG. 7-B

FIG. 7-C

FIG. 7-D

FIG. 7-E

FIG. 7-F

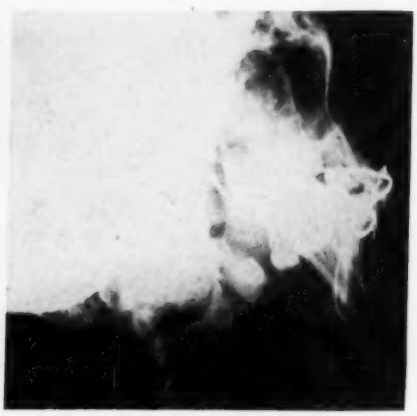

FIG. 7-G

Unilateral shortening of mandible, left side, due to osteomyelitis in infancy. Present age, twenty years. *A*, *B*, and *C*. Casts of teeth showing marked retro-occlusion and displacement of lower teeth to left. *D*. Profile before treatment, showing backward displacement of chin and projection of upper teeth. *E*. Front view before treatment, showing deviation of chin to left and projecting upper teeth. *F*. Radiograph showing rudimentary mandible on left side. *G*. Radiograph after osteotomy and fixation of chin in forward position by circumferential wire attached to upper teeth. *H*. Profile after osteotomy. *J*. Front view after osteotomy. Osteoperiosteal graft has recently been inserted.

FIG. 7-H

FIG. 7-J

the bone on the lingual side, until the mucous membrane of the floor of the mouth is pierced. The trocar is then removed and one end of a twenty-four-gauge brass wire is threaded through the cannula from below. The cannula is withdrawn, leaving the wire passing up into the mouth on the lingual side of the bone. The trocar and cannula are then passed downward from the mouth close to the bone, this time on the labial side, to emerge at the original skin opening. The other end of the wire is then passed up into the mouth through the cannula and the cannula withdrawn. In this way the wire embraces the symphysis of the mandible. By traction on the two ends of the wire, the bone is drawn up until the lower teeth are in occlusion with the upper and the ends of the wire are twisted around the appliance on the upper teeth. The circumferential wire is well tolerated and may be retained for several weeks, the skin incision frequently closing without suppuration.

Retention of the short posterior fragment, particularly if it is edentulous, frequently presents difficulties. This fragment has a tendency to be drawn upward and inward by the elevator muscles of the mandible, until the overlying soft tissues meet the occlusal surfaces of the upper molar teeth, and there is a concavity in the external contour of the face. The interposition of metal, vulcanite, or other material in the mouth to keep down the elevated fragment, frequently produces marked irritation and even pressure necrosis of the sensitive gum tissue. The most satisfactory way to overcome this upward and inward displacement has been recently suggested by Darcissac[8], and we have employed it with success in two cases (Fig. 5). Through small skin incisions each angle of the mandible is exposed and a hole drilled through it for the passage of a twenty-four-gauge brass wire. Each wire is connected with its fellow of the opposite side around the back of the neck by a heavy elastic band. This makes sufficient traction to overcome the upward muscular pull and hold the short fragment down and out in satisfactory position. Here again, the wire produces no

FIG. 8-A

FIG. 8-B

FIG. 8-C

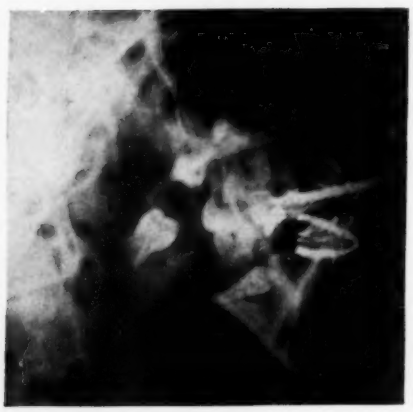

FIG. 8-D

FIG. 8-E

FIG. 8-F

FIG. 8-G

FIG. 8-H

Unilateral shortening of mandible, left side, in boy fifteen years of age, due to injury to neck of condyle by fall in infancy. *A*. Profile before treatment, showing lack of development of chin as compared with upper jaw. *B*. Full face view before treatment, showing deviation of chin to left. *C*. Full face view before treatment, showing deviation of lower jaw to left with mouth open, no ankylosis. *D*. Radiograph after osteotomy and forward fixation of chin by wires on upper and lower teeth. About two centimeters gap in bone. *E*. Radiograph after bony defect filled with osteoperiosteal graft from tibia. *F*. Full face view with mouth open after treatment. *G*. Full face view after treatment showing restoration of symphysis to midline. *H*. Profile after treatment.

untoward irritation in the soft tissues and may be allowed to remain until the bone graft operation is performed.

So far, six cases of unilateral mandibular shortening, due to lesions suffered in childhood, have been treated by the methods described above. Four of the cases followed osteomyelitis of the mandible, due to dental infection. In two of these there was continuity of the mandible, but shortening of one side was present; consequently osteotomy had to be performed as a preliminary to reduction (Fig. 7). In one case spontaneous bone growth bridged the gap. In another the gap was filled by an osteoperiosteal graft. In the other two postosteomyelitis cases there was nonunion, requiring division of fibrous tissue followed by bone grafting (Fig. 6). One patient had a unilateral retarded growth of bone, following an early injury near the neck of the condyle (Fig. 8). Osteotomy was done just in front of the angle, followed by bone grafting. One patient, aged twenty-eight, had a unilateral defect of three inches, from removal of a section of the jaw for tumor at the age of eight. This was corrected by a graft from the crest of the ilium.

CONCLUSIONS

1. Several conditions occurring in childhood may produce a unilateral shortening of the mandible, giving a deformity very similar in appearance to that found in ankylosis, but without limitation of motion of the jaw. Among these conditions are osteomyelitis and necrosis, fractures, and operative removal of a section of the mandible for tumor.

2. Marked improvement in function and appearance can be made by preliminary osteotomy or division of scar tissue to bring the chin forward and to the midline, followed by restoration of continuity by bone grafting.

3. The two most suitable forms of bone graft for the mandible are the osteoperiosteal graft from the tibia and the thick graft from the crest of the ilium.

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DISCUSSION

DR. VILRAY P. BLAIR, St. Louis, Mo.: I appreciate the honor of being asked to discuss a paper by Dr. Ivy before this Association.

He has so well presented the immediate pre-operative and postoperative conditions that it forces me, therefore, to discuss the subject from a broader standpoint. He put it conservatively when he said the most common etiology is dental infection. I think the usual cause is a periapical infection, plus too early operative interference. This may be interference with the defensive mechanisms, by which the body attempts to limit the area of bone destruction; interference with the natural support, by which the contour of the lower jaw is preserved during the reconstruction period; interference with the remaining osteogenetic tissues, which are so rarely completely destroyed by the bone infection; or interference with the live tooth buds, which if let alone will frequently carry on in spite of the surrounding necrosis.

Early use of the knife or curet will often spread the area of necrosis. If the dead bone is taken away before the newly formed bone has gained strength, when the necrosis involved a full thickness section of the body, the bone is apt to crumple in this area. If there is too active use of a curet or knife in the early removal of the dead bone, there may be failure of regeneration, a thing that will seldom occur where the remaining tissues have not been traumatized. If the tooth buds are lost during the growing period, the bone will fail to grow in that area.

The above suggests that the deformity which Dr. Ivy is discussing is a growth deformity in most instances, and we should at least be sure that the treatment which we use in the period immediately following the infection will not increase the potential deformity.

In many cases, where the deformity is fully developed, we can supplement bone cutting and grafting operations by the implantation of cartilage or dermal grafts, and by switching of soft tissues to overcome the distortion of the soft tissues which accompanies this type of abnormal facial development.

OBSTETRICAL PARALYSIS

Some Factors in its Production, Progress and Treatment*

BY GEORGE D. F. MCFADDEN, M.B., M.CH., F.R.C.S., BELFAST, IRELAND

A voluminous literature has gathered around this little tragedy in the midwife's art. The subject has been so well aired by the blast of criticism from all parts of the surgical world, and has been so sifted that it is with some diffidence that I dare to gather up again the many faded fragments of such a well worn subject. The majority have been examined before. Some have been cast aside. Others have been picked up and used as sound material in piecing together our knowledge of its cause and treatment. Yet our knowledge is still uncertain; the actual lesion is not definitely accepted; the treatment is unsatisfactory.

Most papers on this subject have given a review of the preceding literature. This has been ably done by Clark, Taylor and Prout; Fairbank; Platt and others. I do not wish to recapitulate. The lesion is undoubtedly one produced during the act of delivery. It is not produced *in utero*. The baby delivered by Caesarian section does not run the risk of this daily reminder of his birthday.

The condition is uncommon. Duval and Guillain in 1901 reckoned it occurred in about one in every 2,000 births. It is a malady of the result of the extraction of the foetus through the natural passages of the mother. There are four variable factors at work here. Children vary in size: Mothers' passages vary. Uterine force varies. Midwives differ. In spite of such variations, one can account for the condition occurring in several members of the same family. Here the passages are alike, the children resemble each other, probably the same accoucheur is employed. In fifteen cases investigated, two were in the practice of the same doctor, and two occurred in the same family.

The only causative factors we can influence in these cases is the midwive or accoucheur. The other factors are beyond our control.

One or two cases have been reported as occurring in a natural or precipitate labor. The expelling force of the uterus has been estimated by Haughton as 577 pounds. On the other hand Schatz, using an intrauterine manometer, estimated the force during a contraction as twenty-seven pounds; this force increasing rapidly as the foetus gets partly expelled. The energy to restrain a foetus during birth rarely exceeds fifty-one pounds. Joulin attached a gauge to the handle of his midwife's forceps and estimated the pull to extract a child to be between eighty and one hundred pounds.

*A paper read before the British Orthopaedic Association, May 1927.

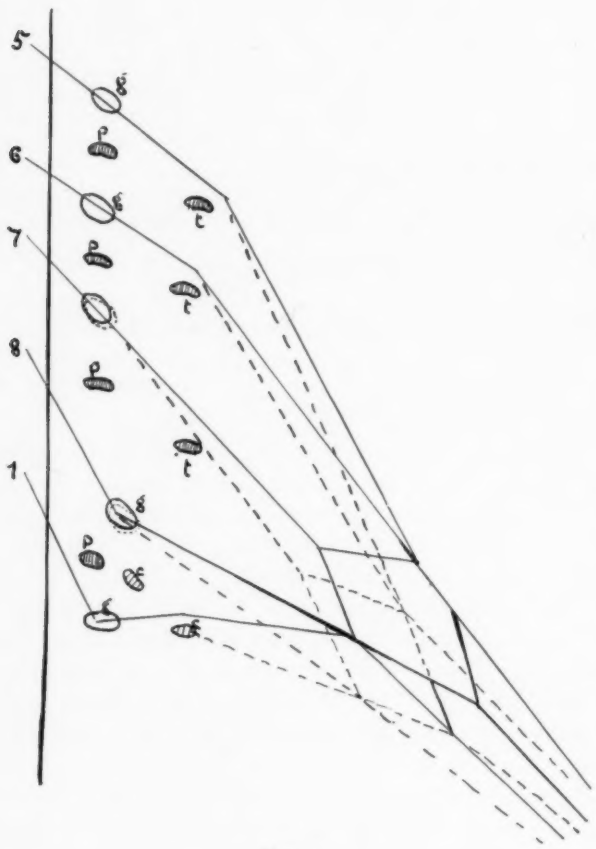

FIG. 1

Diagrammatic representation of the angulation, in the coronal plane, made by the constituents of the brachial plexus in their exit from the spinal cord (after Duvall and Guillain). In many cases the angulation changes with the eighth cervical instead of the seventh cervical nerve.
T—Transverse process. *P*—Pedicle. *G*—Ganglion.

One hundred and twenty pounds' force was sufficient to separate the child's head from its body. We can estimate then the force during a precipitate labor as about eighty pounds. If in this precipitate labor the head is suddenly expelled, the increasing uterine force brings the child against the brim of the pelvis. The condition is like that of one patient in my series who got struck when riding a motor cycle by a lamp post in the front of the shoulder. He had a complete brachial plexus tear.

It would be convenient at this time to touch upon a few anatomical points in the mechanism of the spine and shoulder girdle that have a bearing on the cause of an injury to the plexus. If a close study of the anatomy of the lower cervical and upper dorsal area is made, it will be noted that the intervertebral canals, in the region corresponding to the brachial plexus, are longer and bear a different relation to the axis of the spinal canal than those in other parts. Also, each intervertebral canal in the plexus area varies. The fifth or uppermost canal makes an acute angle with the axis of the spine, and this angle becomes less acute in each succeeding segment. When the arm is by the side, the downward direction of the intervertebral canal corresponds to that shown in the diagram (Fig. 1). When the arm is abducted, the line of the nerves from the intervertebral canal to the axilla remains practically unaltered. This is due to the blending of the fascia around the plexus with that in the axilla and the consequent

fixation of the nerve mass there. As the arm is abducted, the upper trunks become slacker and the lower trunks more taut. In this movement the head of the humerus comes to press against the nerves and acts as a process round which the nerves turn. Consequently it is in the axilla at this point that the strain is most severe when the arm is above the head.

If pressure be exerted laterally on the head and at the same time a strong pull be made on the arm as it lies by the side, the uppermost fibers of the plexus will tend to tear. When the arm is uplifted above the head these fibers are under least tension and the lowermost fibers are most in danger of rupture.

With a pure drag on the plexus, it is exceedingly difficult to rupture the plexus. There are some other factors that enter more largely into the mechanism, as it appears to me to occur in midwifery practice.

A critical examination of the cervical vertebrae will show you another interesting point about the lower ones. In the lower cervical segments, the nerves, as they pass out from the cord, pass in a marked degree obliquely forwards (See Fig. 2). In the first dorsal the nerve passes out transversely, and then takes an acute turn forwards to cross the first rib. In the higher cervical and in the other dorsal segments, the direction is transverse (See Fig. 3).

Rotation of the vertebrae then will put a more marked strain on the nerves in the fifth, sixth and seventh segments than in the dorsal or upper cervical nerves.

Another point of interest is that in extreme rotation of the head in infants, the rotation occurs around a centre at the second or third dorsal vertebra. This centre of rotation is practically on a level with the first dorsal nerve. It is well outside the axis of the fifth cervical nerve. Rotation of the head will then cause a severe strain in the fifth cervical nerve and practically no strain in the first dorsal nerve.

Rotation also brings another factor into consideration. The large transverse process of the seventh cervical vertebra lies directly behind the junction of the fifth and sixth cervical roots. If the head is rotated, this process presses forwards against this point and increases the strain.

Through these factors rotation has, then, an extremely important bearing in the production of tears in the upper roots of the plexus. It has a much more important rôle than has hitherto been assigned to it.

Undoubtedly the greatest amount of strain on the upper roots is obtained by any force that increases the angle between the head and the shoulder. The center of movement of the neck being about the level of the second dorsal vertebrae, this strain is decreased or increased, if the head is rotated to face towards or away from the shoulder concerned, and varies with the position of the arm. The patient cited above, who struck his shoulder against a lamp post in a motor cycle accident, got a complete tear of the plexus. Here it would seem that rotation might have been the sole cause of the injury. A nurse who had two cases of Erb's paralysis in her practice stated that she considered the lesion to occur when the shoulders

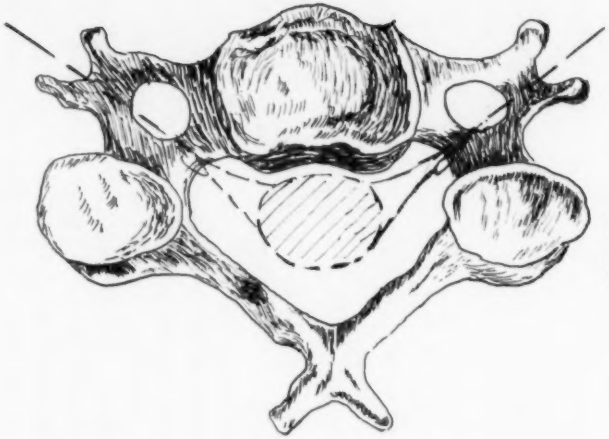

FIG. 2

Lower cervical vertebra, showing the forward direction of the nerves as they leave the spinal canal.

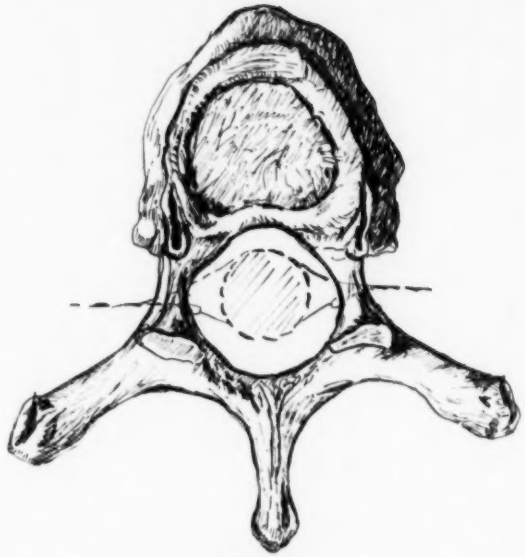

FIG. 3

Dorsal vertebra, showing the practically transverse direction of the nerves as they leave the spinal canal (Quain's Anatomy).

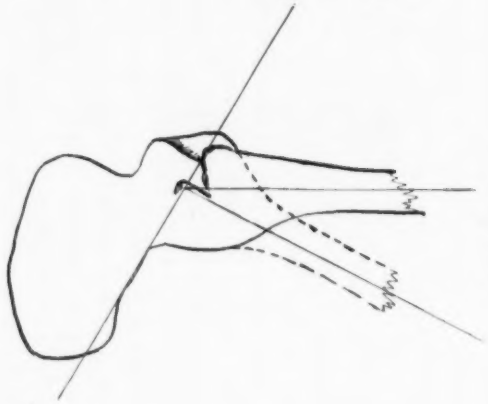

FIG. 4

Silhouette drawing of the shoulder joint of a full-time foetus, showing the amount of abduction obtainable with an internally rotated humerus, compared with that in which the humerus is in almost complete external rotation.

failed to rotate. She had tried in both her cases of Erb's paralysis to bring about the rotation of the shoulders by twisting the head of the infant. By experimenting with lately dead foetus, I found that the lesion is most easily produced when one combines a downward drag on the arm in a direction that increases the angle between the head and the shoulder, with rotation of the head away from the arm dragged upon.

The most common lesion produced is a fraying of the uppermost fibers of the plexus; these form the suprascapular nerve. Occasionally the most anterior part of the joint root of the fifth and sixth cervical is frayed. Some of these fibers run into the musculocutaneous nerve. If the shoulder is markedly braced back, the suprascapular nerve is made especially taut and the nerve comes off at an angle from the trunk. If pressure is then applied by the fingers over the plexus, the nerve may snap or it may strip up to the root.

Regarding pressure on the plexus by the clavicle, this does not appear from my study to be a likely cause of the lesion. The clavicle is the first bone in the body to ossify. It is an exceptionally strong little bone for a foetal bone. It has a strengthening arch which protects the underlying structures. Indirect pressure will not allow the clavicle to press upon the nerves. The structures underneath are protected by their slippery surroundings of fat, and the bone is so strong that it will not give readily to direct pressure. The clavicle does not rise to the level of the fifth and sixth roots. Thus actual pressure by the clavicle on the plexus is practically impossible.

I know of no case where a typical Erb's paralysis was associated with a fractured clavicle. Eversmann had a case with a fractured clavicle and an intact plexus on that side. On the other side there was an Erb's paralysis with an intact clavicle. In fact, I think fracture of the clavicle often saves the plexus.

All the cases investigated were, with one exception, vertex presentations. In vertex presentations it is in the delivery of the shoulders that the lesion is caused. This difficulty with the shoulders is usually due to absence of rotation of the shoulders, occasionally to an excessive shoulder girth. The midwife, to deliver the shoulder, depresses the head to try and bring the shoulder down under the symphysis; at the same time, attempting to do what he considers nature has failed to do, he tries to rotate the shoulders by rotating the head. This puts the plexus in the best possible position for rupture.

In a breech delivery the arm may be locked behind the head in the nuchal position. The accoucheur in such a case brings down the posterior arm and then does what is advised by text-books on obstetrics,—he rotates the body to bring the anterior arm posterior, at the same time continuing the downward pull on the body. In this movement the body is twisted, and the head is fixed in the pelvis. A great strain is again placed on the plexus, this time in the region of the shoulder joint, the fibers from the first dorsal segment being most taut. When the shoulders have

been delivered in a breech presentation, a pull may be made on the body to try and hasten the delivery of the head. The accoucheur is usually in haste here, for he fears asphyxiation. He pulls lustily and hurriedly, lifting the body forwards or backwards; in so doing he increases the angle between the head and the posterior or anterior shoulder. At the same time he may try to help rotation of the head by rotating the body. The head is frequently tightly grasped here also and the result is an excessive torsion of the spine around the third dorsal vertebra. It is this hurry that raises the percentage of cases in breech deliveries. Guillemot in 1897 told of a midwife who had thirty cases of Erb's paralysis in his practice. In America more emphasis has lately been put upon not hurrying the delivery of the head. Asphyxiation is not such a real danger. One obstetrician, quoted by Williams, allows up to twenty minutes for the delivery of the head. If this teaching were more general the "babies' breech would not often spell disaster".

Another point of danger in the delivery of a breech is the final extraction of the head. In the Prague method and Mauriceau Smellie-Veit method the shoulders are well braced back, and the grasping fingers may press on the taut plexus, giving rise to a snapped suprascapular nerve or a stripping up of the nerve.

Some cases of obstetric paralysis are due to injury of the spinal cord at birth. A strong pull of 120 pounds in the direction of the spinal canal will sever the child's head from his body, and lesser forces will cause injury to the spinal cord. In a series of 800 cases, Sharpe and Maclaire found blood in the cerebrospinal fluid in 112 cases. Ford and Boyer reported in detail a case of paralysis due to partial rupture of the spinal cord. Crothers believes that death may be caused during delivery by the medulla being pulled down into the foramen magnum.

I have operated upon the plexus in one case. This baby had at first a complete paralysis of the arm. The lower arm paralysis cleared up, and the upper arm condition remained stationary. This pointed to a gross lesion of the upper roots. At operation I found a bulbous swelling involving the fifth root and extending down to the junction of the fifth with the sixth root. I resected the fifth root just outside the intervertebral canal to where the sixth root joined it, and did an end-to-end anastomosis. This operation finding was like that found in Clark, Taylor, and Prout's cases. Kennedy and other operators have found a like condition of the plexus.

Turner Thomas cast great doubts upon the lesion being due primarily to a tear in the plexus. He considered that it was secondary to an injury to the shoulder joint. Tears and frayings of the nerve plexus have actually been found at operation and are produced experimentally in conditions allied to an obstetrician's delivery. A subluxated shoulder in a case of obstetric paralysis is not seen under three weeks of age. In fifteen cases investigated, it was not found under ten months. I know of only one case of a dislocated shoulder at birth. Here the accoucheur had such great difficulty in bringing down one of the arms, that he thought he might have

injured it. The next day the house surgeon noted that the shoulder was dislocated. There was no associated paralysis of the arm. The dislocation was reduced. Unfortunately the baby died three days later, so we do not know whether it would have presented the clinical features of Erb's paralysis.

According to Turner Thomas's theory, the paralysis should not show itself till some days after birth, yet the paralysis of the limb has been noted as soon as the child is born. It is much more in accordance with scientific facts to regard the shoulder joint condition as secondary to an injury of the plexus. This is an incomplete injury to the nerve supply of the shoulder joint. Consequently we should expect the changes found experimentally by Raymond and Onanoff, and clinically drawn attention to by Ogle, Tinel, etc., *viz:*—contractures of the joint capsule, muscular and bony atrophy and interference with the growth of bone (See Figs. 5, 6 and 7). All these changes are well marked in all cases of obstetrical paralysis examined, except two, which had a complete lesion of the nerve supply of the joint, and in which the joint structures were comparatively loose. It is noteworthy that the more severe the injury to the nerve, the less the changes in the shoulder joint. The incomplete nerve injury gives rise to the so called "irritated joint" with its contractures of the capsule and muscle atrophy.

There are a few points about the anatomy of the shoulder joint that have not been sufficiently or clearly stressed in anatomical writings, which, I hope, will help us in understanding the peculiar functioning of the shoulder

FIG. 5

Skiagram of shoulder joints of child, aged five months. It shows the effect of the nerve lesion on the growth of bone. Compared with the normal, the diaphyseal end shows lipping and some sclerosis. The epiphyseal center is hardly visible, although well seen on the opposite side.

FIG. 6

Skiagram of older child, showing typical changes.

joint in these cases with obstetrical nerve injuries to the brachial plexus. In the majority of the cases examined, there was no active abduction, yet there was free passive movement and an unwasted deltoid that could be felt to contract.

The capsule of the joint is a loose-looking structure. In the full-time foetus it allows a separation of one-quarter inch between the bend of the humerus and the glenoid. To glance at the joint, one would consider that movement would be excessively free, were it not for the surrounding muscles. Yet with the muscles cleared off the joint, movement is the same

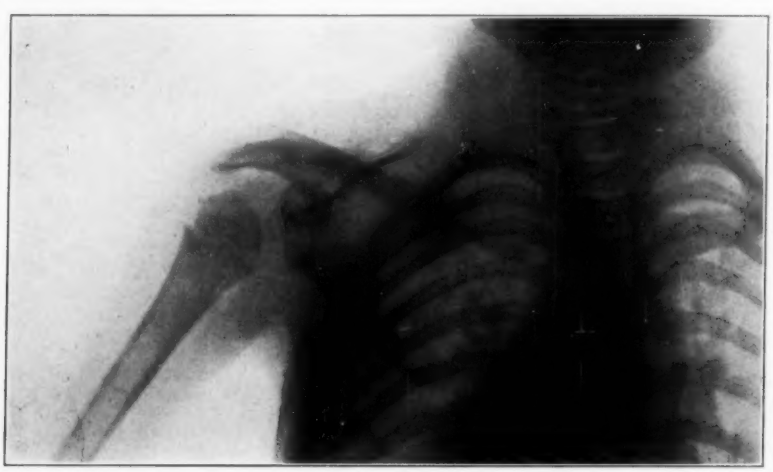

FIG. 7

Skiagram of child aged six years and seven months, with a typical deformity.

in all directions as when the muscles had their normal attachments. The range of movement in the joint is the same whether it is measured in a child with a flail shoulder, the result of infantile paralysis; or in a child with a normal musculature; or in the freshly dissected shoulder joint specimen. Muscle tone does not therefore limit the movement, muscular attachments do not limit it, bony contact does not take place in extreme movements between the lip of the glenoid and the neck of the humerus. It is the capsule itself that is responsible. The range of movement is as follows:—

Abduction (with the humerus internally rotated)	95 degrees
Abduction (with the humerus externally rotated)	120 degrees
Flexion	45 degrees
Range of rotation	180 degrees

It is difficult to dislocate the head of the humerus from the glenoid in the freshly dissected specimen. There is no lever to use like the long neck of the femur fulcrumed by the Y-shaped ligament of Bigelow. The best lever fulcrum in the shoulder joint is the lower part of the capsule. I am inclined to think that it is this anatomical fact, and not the surrounding muscles, that determine why a dislocation of the shoulder joint takes place at the inferior part of the joint. Clinically all dislocated shoulders take place with the arm in an abducted position. If the joint owes its stability to the surrounding muscles, it might also owe an instability to the spaces between these muscles; besides, muscles are soft, yielding structures. It is the peculiar attachment of the capsule and the disproportionate size between the head of the humerus and the glenoid cavity that give stability. The coracohumeral ligament runs downwards and backwards from the glenoid to the humerus, and so limits rotation externally. The inferior fibers of the capsule run from the glenoid in front downwards and backwards, to be inserted well down on to the posterior aspects of the surgical neck of the humerus. It is this low insertion that causes this apparently very loose part of the capsule to limit abduction. If the humerus is in internal rotation, these lower fibers will be tightened and shortened, and so abduction in this position is some twenty-five degrees less than when the lower fibers are loosened by external rotation of the humerus (See Fig. 4). Now, if to this joint in marked internal rotation, one adds the contractures of the capsule secondary to the nerve injury, the abduction is greatly decreased.

In the active movements of the joint all muscles are concerned. The deltoid is practically useless without its comrade muscles. Its anterior and posterior fibers must be adductors of the humerus. The acromial fibers in certain positions have some abducting power, yet in the hanging position of the limb it is in practically a neutral phase and the only action of the muscle is to steady the head of the bone in the joint. The supraspinatus steadies the head, pressing it down, and acts as a true abductor. Practically all fifteen cases of obstetrical paralysis that I have demonstrated had an actively contracting deltoid muscle, a good number had free passive movement of the shoulder joint. Yet only one had a slight amount of free

active abduction. In all other cases, when abduction was attempted, the joint was kept stiff and the scapula moved. This is just what one would expect from the foregoing anatomical facts.

The long head of the biceps has no abducting power; the action of the long head of the biceps appears to me to be demonstrated by one case.

This girl had an acting biceps like most of the cases. She had had an operation some years ago on her shoulder joint with an ankylosis as a result. She could flex the elbow joint within twenty to thirty degrees of full flexion, yet could not complete the movement. On attempting to complete the movement, she had pain over the long head of the muscle. Full flexion was easy to obtain passively. The pain only occurred when the last degree of flexion was attempted. It would appear that it was at this stage that the long head was called into action.

In none of these cases of Erb's paralysis were the children able to put their hands behind them to touch their spines. One child could complete the movement if the arm was slightly abducted to bring it behind the flank. This patient had an upper and lower arm lesion. There was only slight contracture to the shoulder joint. This movement is permitted in the normal joint by the loose capsule. The head of the bone rides forwards and outwards when this movement is made. A contracted capsule or the head of the humerus subluxated backwards will naturally prevent this. Both these conditions, or one of them, are present in all the cases examined, except the one that showed recovery, and the one severe case noted above in which there was very little contracture.

Out of fifteen cases collected, there were twelve female children to three males. Five had some lower arm involvement at the beginning. The lower arm lesion had cleared up in all but two cases. Three had some loss of free movement at the elbow joint, due to a slight subluxation of the head of the radius.

Every one had an acting biceps and all but one had an acting deltoid muscle. Only the two cases with lower arm involvement had loss of power of supination. No action could be detected in any of the spinati muscles, except in one case, now aged four months, which seems to have had a complete recovery. In twelve of the remaining fourteen cases, the lesion could be narrowed down to a peripheral suprascapular nerve injury, or an injury of the fifth root. The result of such an injury is the loss of the true abductors and of the external rotators of the humerus. The typical deformity is then one of marked internal rotation with abduction.

In the normal state, the head of the humerus is centered on the glenoid by the balance thrust of the surrounding muscles. In the suprascapular nerve injury there is left only the backward thrust of the subscapularis muscle and the slight upward thrust of the long head of the triceps. In time the head of the bone gets driven gradually backwards, and the typical subluxation is produced. This subluxation was not present in any of the cases under ten months of age. It was present in all the unoperated cases over that age, except in two patients who had practically flail shoulders.

If to these disabilities of a suprascapular nerve injury are added those following upon an incomplete or irritative nerve injury, the true clinical condition of the shoulder joint is obtained, which is as follows:—

1. There is no true abducting muscle acting on the joint.
2. The humerus is rotated inwards and markedly adducted.
3. The subscapularis muscle and pectoralis major muscle are contracted.
4. The lower fibers of the capsule are tightened by rotation, and the whole capsule by the contractures secondary to the incomplete nerve injury.
5. The head of the humerus is interfered with in growth, causing a change in its shape, and it tends to be subluxated backwards (See Figs. 5, 6, and 7).

This is for practical purposes a joint ankylosed in adduction and internal rotation.

Greater nerve damage than a pure suprascapular nerve lesion does occur, but it appears less common than is supposed. In all cases over three months of age the biceps are acting, and in all but two the deltoid and supinators.

It is often wrongly stated that these children have loss of power of supination. The supinator muscles are acting, but on account of the fixed internal rotation of the humerus the palm cannot be made to face upwards.

I have shown how, from an anatomical point of view and from experiments, the suprascapular nerve is most likely to be injured. If the nerve was only stripped up, a temporary paralysis would be expected as a result of the traumatic inflammation. This temporary paralysis occurs in about twenty-five per cent. A laceration of this nerve or its continuation in the upper root of the plexus would mean a disturbance in the neighboring nerves as well. This neighboring disturbance would clear up as the hemorrhage was absorbed and the traumatic inflammation subsided. These cases have, then, a wider spread paralysis at the beginning, which in time clears up except for the muscles supplied by the lacerated nerves. It also follows that the more widespread the paralysis at the beginning, the more severe is the actual damage to the nerves.

TREATMENT

In considering treatment, prevention is better than cure, for no complete surgical cure is known, once the nerve tissue is destroyed. Midwives should be taught to realize that a force of seventy pounds weight is practically a maximum. In applying this force the accoucheur should *not tend to increase the angle between the head and the shoulders and he should avoid rotating the head away from the shoulder pulled upon.* If the head is rotated towards the shoulder concerned, the strain on the plexus is lessened.

In the delivery of difficult shoulders, the head should not be twisted and pulled upon to try and cause the shoulders to rotate and descend. It is better practice to pull with a finger in the axilla or even to fracture the clavicle, when there is great difficulty with the shoulders. In delivery of an after-coming head with the hand in the nuchal position, the head should not be rotated by twisting the body in an attempt to bring the anterior shoulder posterior. In breech cases the same care should be exercised as stated for vertex cases. Here hurry is the mother of disaster. When replacing in the normal position a cord that is around the neck, extreme care should be exercised when performing the dangerous movements noted above. In the Mauriceau Smellie-Veit and in the Prague methods of extraction of the after-coming head, care should be taken to see that the fingers do not press on the taut brachial plexus and thus bring about a stripping up or a laceration of the peripheral suprascapular nerve.

Regarding surgical treatment, the arm should be placed in a splint for three months to rest the paralyzed muscles. The platform splint is the best yet devised, but it is not completely satisfactory. It is difficult to keep it from allowing the arm to get in front of the body. When splinted the shoulder joint should be put through its full range of movement twice a week to keep the capsule stretched.

If the paralysis is widespread or if the whole limb was at first paralyzed and has cleared up, leaving an upper arm paralysis,—signs that point to an injury to one or several of the nerve roots,—an exploratory operation should be undertaken. The resuturing of a damaged nerve trunk in a baby is not difficult. In the less severe injuries, as in a pure suprascapular nerve injury, it is difficult to suture the nerve, and exploration does not seem satisfactory. In these cases the disability is mainly:—

1. The subluxation backwards.
2. The internal rotation and abduction.
3. The contractures.

These are all complications of the nerve injury. A division of the subscapularis tendon with possibly a division of the long head of the triceps and an incomplete division of the pectoralis major are indicated. If this is done early, all the above causes of disability, namely subluxation, internal rotation and contractures will be avoided. If there is yet little contracture of the capsule, it need not be divided; a cut from below obliquely upwards and inwards will avoid the subscapularis bursa. If the capsule is contracted, it should be divided at its lowest part anteriorly when dividing the tendon. These operations must be followed by continuous passive and active movement to prevent the formation of adhesions. If the movements are not practised, adhesions take place and the result is practically an ankylosis of the joint.

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AN OPERATION FOR THE REDUCTION OF CERTAIN TYPES OF CONGENITAL DISLOCATION OF THE HIP*

BY PAUL P. SWETT, M.D., F.A.C.S., HARTFORD, CONN.

In open operations upon older children for congenital hip dislocation, difficulty is often found in effecting a reduction of the femoral head into the acetabulum. In spite of abundant freeing of the joint capsule and wide dissection of the muscle attachments, followed by vigorous traction and prying of the head of the femur, it has often been impossible to reduce the femoral head. Or, if the reduction could be completed, it was only with so much trauma to the articular cartilages as to seriously jeopardize the articular integrity. It is not to be understood that these embarrassing conditions have obtained in all open reductions but, in my hands at least, they occurred with such frequency as to give food for much thought, whenever I was confronted by the necessity for an open operation in a well grown child past the age, or past the anatomical development, for a manipulative reduction.

In July 1926, a small, wiry, twelve-year-old child was admitted to the Newington Home for Crippled Children. She had double congenital dislocation of the hips. The femoral heads were displaced upwards and backwards, but they were essentially normal in shape and in angulation. There was no anteversion of the femoral heads, nor coxa vara or coxa valga. The acetabular cavities were of moderate depth and apparently of good size. On two occasions we manipulated her hips under full ether anaesthesia, but the possibility of reduction was immediately seen to be out of the question, because the soft tissues were so firm and resistant that we could only move the bones a few degrees. It was thought that every effort should be made to complete the reduction, because of the normal shape of the joint surfaces, and it was decided to do an open procedure.

Our idea, when we started with this operation, a few weeks later, was to do such a wide and generous soft-tissue dissection as to reduce to a minimum the need for the use of force or the production of trauma. The right hip was exposed by a Smith-Petersen incision. The outer and upper portions of the capsule were opened widely, and the muscle attachments all about the trochanters were dissected free, and the acetabulum was cleared of redundant capsular tissue. A hooked elevator was then used to pry the femoral head toward the acetabulum, but in spite of strenuous efforts, it became apparent that no amount of force could possibly effect a reduction. That completely loosened femoral head could be made to go in any direction except down. The only apparent explanation was that the soft tissues

*Read at the Annual Meeting of the American Orthopaedic Association, at Washington, May 2, 1928.

FIG. 1

The first case in this series before treatment. This shows the marked upward displacement of the femoral heads with the satisfactory confirmation of the femoral heads and necks and the well constructed acetabular cavities.

were too short for the bone or the bone was too long for the soft tissues. I had never thought of this explanation before, and immediately there came the question that if this were true, why could not we shorten the bone and thus effect the reduction. I at once discussed this idea with my assistants and none of us could see any flaw in the logic, but we decided it would be best to postpone such a radical proceeding to another sitting.

Two weeks later, the wound having healed without infection, we reopened it, divided the soft tissues as before and did a transverse osteotomy below the lesser trochanter. The femoral head was then picked up and thrust into the acetabulum, the fractured ends were allowed to overlap, the capsule was closed tightly and overlapped so as to remove any redundancy. The thigh was immobilized in a long plaster spica in the position of full extension and moderate abduction. This position was continued about twelve weeks, and then all support was removed and the child was allowed to use crutches gradually.

The first x-ray (Fig. 1) shows the hips as they were on admission. Here may be seen the typical double dislocation with the relatively normal femoral heads and acetabula. The second x-ray (Fig. 2) shows the right hip after the shortening operation. The femoral head is in place, the transverse osteotomy is seen to have been splintered on the inner surface, and the bony fragments are overlapped. The transverse osteotomy was

FIG. 2

The right hip in the first case, shortly after reduction while still in plaster. This shows the overlapping of the bone ends at the site of the osteotomy.

FIG. 3

This shows both hips in Case 1, several months after the completed reduction. The osteotomy on the right side is fully healed, and on the left partially healed. The diminution in the joint space on the right side is a result of the trauma caused by two open operations, plus the previous manipulative efforts.

FIG. 4

This is the second case, showing well marked upward dislocations of the femoral heads and shelving shallow type of acetabular cavities before the operation.

elected, however, because of the hope that there would be less disturbance to the nutrition of the femoral head, neck, and trochanters. It was feared that such a complete subligamentous dissection of the muscle and ligamentous attachments and an osteotomy might cut off the blood supply to the upper fragment. Prompt healing of skin, muscle, and bone gave us great satisfaction and we proceeded at once to do the left side in one sitting. The third x-ray (Fig. 3) shows both hips in place with the osteotomies healed.

There can be very little doubt that the disproportion between the lengths of the bone and the soft tissues accounts for the difficulty or the impossibility of reduction of the femoral head in many instances. In the event of an acetabulum of adequate depth, a femoral head and neck of proper shape and angle, with the acetabulum well cleared of redundant capsule; what else could prevent the reduction except that the soft tissues are too short? How often have we all pulled or pried on the femoral head, only to get it opposite the acetabulum and then to have it slip upwards and outwards with great force. It is to be remembered that the adductor group of muscles, the extensors of the leg and the flexors of the leg, are ordinarily not affected by the dissection which frees the attachments about the femoral trochanters. The skin, the fascia, and the blood vessels and nerves all are similarly short. These facts are so self-evident as not to require demonstration; they are mentioned here simply to call attention to them.

When we had assured ourselves of the soundness of this reasoning, it remained only to decide whether an osteotomy and overlapping of the bony fragments could be carried out without disturbance of the nutrition of the femoral head, neck, and trochanters. At first it seemed as if a good deal was being asked of these bony parts in this respect. We reflected, however, that in certain traumatisms of the shoulder it had occasionally happened that the humeral head was fractured off at the anatomical neck and then displaced anterior to the glenoid cavity. In none of these cases had it ever been our experience that the nutrition of the humeral head was destroyed after reduction of the deformity and reapposition of the fragments. Of course the analogy was not perfect, but it seemed to signify enough to warrant making the contemplated trial in the hip. The transverse osteotomy was selected because it would cause less stripping of the muscles and periosteum and thus cause less nutritional disturbance.

The shortening of the femur of approximately one inch did not seem to be a deterrent factor. Of course it was realized that even with this, the reduced hips would make the legs longer than before, and in the double cases the length would be about equal on the two sides.

This first child has been under constant observation ever since the operation, and the result to date is disappointing for several reasons; but, so far as I can see, all of these comprise defects in our early technique. They do not constitute inherent defects in the operation, since it is probable that all of them can be overcome by modifying the original procedures.

The first disappointment was occasioned by the limited motion in the right hip, caused by an extensive fibrosis of the joint, resulting from the two open operations with the extensive scar-tissue formation. That disturbing capsular fibrosis is not an inherent defect in the operation is demonstrated by the fact that the second hip presents a satisfactory range of mobility in all directions. The second disappointment is in the marked degree of internal rotation of the lower femoral fragment. This also need not occur, if care is used in the apposition of the bone fragments and in the alignment of the extremity while the plaster is being applied. In this first case we were so much concerned to prevent the recurrence of the dislocation that we were afraid to adjust the lower fragment.

Another disappointment is the marked degree of coxa vara that has occurred. This seems to have been due to weight-bearing before solid bony union had occurred, although we are not sure that it was not caused by muscle pull. Since it was not apparent before weight-bearing was permitted, probably muscle pull does not explain it, and, if this is true, then this feature too is not inherently a fault of the operation. It would probably be of advantage to apply moderate skin traction inside of the plaster spica for several weeks after the operation and to follow this by a much longer period of non-weight-bearing.

In spite of these detracting features, this child can walk very well, both hips are in place, and I believe that her future will be one of gradually

FIG. 5

This is the same as Figure 4, shortly after the reduction by osteotomy and showing the femoral head well placed in the acetabulum and overlapping bone ends at the site of the osteotomy.

FIG. 6

This shows the left hip of the second case following reduction and shows the marked degree of coxa vara, which was largely occasioned by an accidental fracture through the femoral neck.

increasing good function, rather than the gradually increasing pain and lameness which we are accustomed to see in these cases.

In other words, the functional result is much better than the anatomical result; and the question is whether a reduced hip, even though it is deformed, is better in the long run than an unreduced hip. The result of this operation was sufficiently encouraging to attempt it in other cases.

I can report on five subsequent operations. Two of these later cases were in double hip-joint dislocations and one in a single dislocation. The total number of these operations is seven. The first of the series has been detailed.

The second case was E. B., aged eight. The right side has given a good functional result with free painless motion in the hip. See Figure 4 showing condition before operation, then Figure 5 taken two months after the operation. The left side (Fig. 6) was done a second time, because the femoral head slipped out after the first procedure, and the upper femoral epiphysis was accidentally fractured during the second operation, with the consequence that there is considerable deformity and marked limitation in motion.

In the third patient, D. D., aged four, an excellent functional result occurred on the right side. See Figure 7 taken before operation, and Figure 8 which shows the present condition. On the left side, however, the femoral head apparently slipped forward and has remained in this position.

In the fourth patient a left-sided dislocation was present. This is the seventh operation in the series. The girl was aged fourteen, but there appeared to be a fairly normal shaped femoral head and an acetabulum of moderate size (See Fig. 9). This child was the oldest and much the largest in this group, but no difficulties were encountered whatever. The femoral head was easily reduced as soon as it was freed from the shaft. An uninterrupted convalescence took place, and the anatomical result eight months after the operation is shown in Figure 10.

The greatest disappointment encountered in all this experience concerns the x-ray appearance of the upper ends of the femora. This, of course, was not apparent at first, but as time has gone on there has been a gradually increasing appearance of disturbed growth and development with alterations of shape and form. The femoral heads appear to grow smaller and the femoral necks to become in some cases more, and in some less, angled in relation to the shafts of the bone. Fortunately, however, the function of these hips has not grown less with these apparent retrograde steps and, except for the x-ray, one would have very little indication that they were taking place. In connection with this disappointment, there arises a doubt as to what the distant future may hold for these hips, but there seems no valid reason for supposing that a recurrence of the displacement need be feared.

From these very limited experiences, it is not reasonable to draw

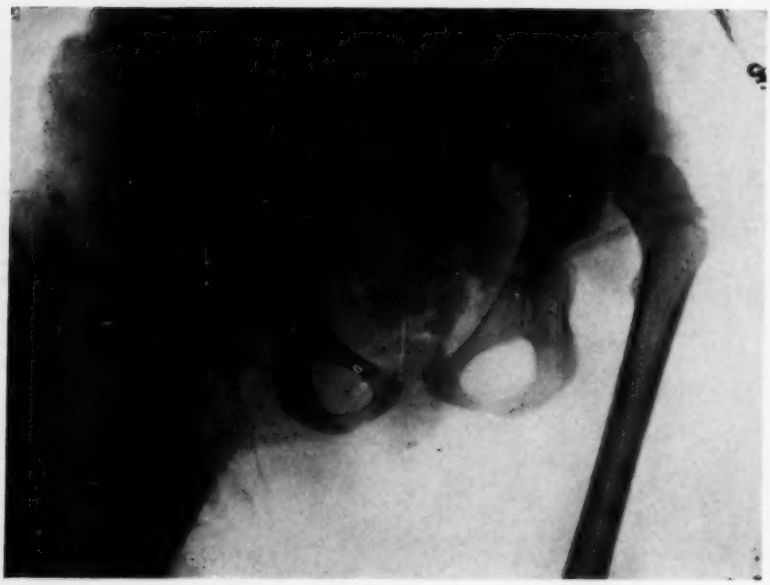

FIG. 7

This shows both hips in the third case, the right side having been reduced by an osteotomy and the left side by an open reduction.

FIG. 8

This shows the present condition in the third case. The right hip is well reduced but there is marked degree of coxa vara. The left hip is in marked coxa valga and the femoral head is anterior to the acetabulum.

conclusions except of the most tentative kind. The results appear to indicate that this operation shows sufficient promise to justify its further use in properly selected cases. It is evident that by this means it is possible to reduce the femoral head in certain instances where otherwise it would be impossible to do so. Further, this has been accomplished only with some resulting disturbances in the subsequent growth and development of the femoral head, neck, and trochanters. Whether these changes are inevitable or whether further experience and some modification of the operation will overcome them, is not as yet determined. The operation itself is apparently unattended by serious technical obstacles or immediate local complications. The period of convalescence is longer than in simple closed or open reduction, because of the delay in solid bony union of the osteotomy wound. The prolonged postoperative care requires very delicate and careful management, and thus far it is not clear just how this can best be carried on. For example, it is quite likely that the apposition and alignment of the fractured bone ends could be improved three weeks after the operation by gentle manipulation and redressing in plaster-of-Paris. Considerable holding capacity of the sutured capsule could be expected if very strong accurate overlapping and suturing were done, and thus there would be less likelihood of the head slipping out of place. It is possible also that the immediate use of moderately strong traction would help to maintain the best amount of rotation, abduction, and extension, if it were applied at once or at the

FIG. 9

This shows the marked upward displacement of the left hip in a fourteen-year-old child with a very shallow and poorly outlined acetabulum.

FIG. 10

This is the same case as Figure 9, showing the reduction and healed osteotomy.

end of three weeks. The operation can probably be improved by very careful measures of suturing the capsule. In these few cases, it must be admitted there has been a feeling of haste and an atmosphere of tension, which have caused less exactness and precision than would be the case in a more familiar situation. Since the first object of the treatment is to keep the femoral head in place, once it gets there, it is likely that this object can be facilitated by very exact handling of the capsule. The capsule in our cases has too often been dissected off the upper border of the acetabulum, leaving very little to sew it back to. This can be avoided by splitting the capsule well out from the upper border of the acetabulum, leaving two broad flaps to be overlapped and snugly sutured together after the head is replaced. It will require some care to leave an adequate upper flap, while removing the redundant layers folded into the acetabulum. If this is accomplished, however, and then the layers are snugly and strongly overlapped and sutured so that considerable force may be used without displacing the head, it will be possible to put the extremity into a plaster dressing in better alignment than was secured in our cases. Again, the position of the upper fragment must be assured against slip or pull by directly attaching it to the lower fragment. For this purpose the osteotomy wound ought to be long and oblique, so that the overlapping ends can be snugly fitted together and held in place by two through-and-through ties of very strong kangaroo tendon.

As to the selection of the candidates for this operation, there are certain fairly well defined criteria to be mentioned, but it is by no means certain that these are complete or final. Further experience may enlarge

the field or it may limit it very sharply. Thus far, however, it appears that there must exist an acetabulum which in the x-ray can be seen to be of sufficient circumference and depth to receive the femoral head. But this must be qualified, because cursory examination of the x-ray film may seem to show only a very shallow and ill-defined acetabular cavity, which upon opening may be found much deeper. This was well illustrated by one of our cases. Here was thought to be a very rudimentary acetabulum, which upon exposure was found of sufficient width and depth to hold the femoral head. It is not apparent how one can tell definitely, but it is suggested that in case of doubt, an exploration should be made. The next selective criterion concerns the age of the patient, but this is less important in its chronological aspect than in the extent of growth and development. There are some children of four whose development is greater than others at six or seven; and others who show less mobility of the displaced femur at four than some at six or seven. So far as is now apparent, there are no valid reasons why a child of four, in whom a vigorous attempt at closed reduction has failed, should not have this procedure attempted, if it is impossible to complete the reduction by an open attempt. As to the upper age limit, it appears to be less a question of age than of the development, but we have done one case at fourteen and we should not hesitate to do it at any age if the x-ray seemed to show an acetabulum and a femoral head of such sizes and shapes that they could be fitted together. In fact, it appears likely that less subsequent distortion of the upper end of the femur will result in the older cases than in the younger ones.

Another indication for this operation would appear to occur in the cases of anteversion of the femoral head and neck. Thus far we have not done it in such a case, but there seems to be every reason to suppose it would be quite successful in this type, and this proceeding could be furthered by a very careful selection of the direction of the osteotomy.

Only tentative conclusions can be drawn from these cases, but the operation thus far appears to merit further trial. It is, therefore, in a spirit of inquiry that we bring it forward at this time, and in the hope that others may employ it in selected cases and thus provide a large amount of experience upon which to base further conclusions. When the idea of this operation first occurred to me in the midst of an unsuccessful attempt at an open reduction, it did not seem best to carry it forward because the proceeding seemed so simple and logical that I could not help feeling that it must have been done already and discarded. So I looked up the literature and talked to various colleagues without finding any previous reference to it.

CONCLUSIONS

1. This operation, so far as I have been able to learn, is here reported for the first time.

2. The basic principle of the operation consists in the adjustment of the disproportion between the lengths of the bones and the soft parts by means of an osteotomy below the femoral trochanters.

3. It provides a means for the reduction of a type of case which previously it was impossible to do either by manipulation or operative means.

4. The cases included in this type are the older or more developed children who present acetabula and femoral heads of fairly normal shape and relative size.

5. The success of the operation appears to depend upon the careful clearing of the acetabulum, gentle and accurate transection of the mid-portion of the joint capsule, strong suturing of the overlapped capsule, and proper approximation and alignment of the bone fragments.

6. The cases as yet are too few and too recent to prophesy the future of this operation, but the only apparent obstacle to a considerable range of usefulness lies in the possibility of too great a degree of disturbed or altered growth and development of the femoral head, neck, and trochanters.

NOTE: This paper was discussed with the papers presented by Dr. Allison and Dr. Gill. See page 707.—*Editor.*

THE ADAPTIVE CHANGES IN THE HIP IN CONGENITAL DISLOCATION AND THEIR IMPORTANCE IN TREATMENT*

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End-result studies made on individuals who have reached maturity and on whom one or another type of manipulative reduction has been resorted to in early childhood, make it clear that there is room for improvement in the results. Indeed, the results are not sufficiently satisfactory to allow of any degree of complacency regarding them.

Better results will be secured only by the general usage of better methods of reduction and after-treatment.

The object of treatment is the reduction of the dislocation. It is generally agreed that reduction should be accomplished at the earliest possible time.

It is also generally acknowledged that the reduction should be accomplished with the least possible injury to the growing bones.

The obvious reason for early reduction is that growth and development so change the upper end of the femur that reduction becomes increasingly difficult. The constant trauma of function in the unreduced hip also produces marked changes in the growing epiphysis.

The obvious reason for avoiding force at the time of reduction is that the upper femoral epiphysis may be markedly changed by the injury thus given the delicate epiphyseal region. This applies to any type of procedure, either manipulative or open reduction.

The chief object of treatment is a return of useful function to the hip after reduction is accomplished. To this end it is important that the period of fixation in plaster-of-Paris be reduced to the minimum. Bone changes which result from long periods of non-use, especially when fixation in plaster-of-Paris prevents function, are unquestionably present and add considerably to the sum-total of lasting disability.

Long ago, certain age limits were set for the manipulative treatment. This age limit has been generally accepted as variable with certain conditions, such as the muscular development and growth of the child. The limit set for double cases is the seventh year, for single cases the ninth year. The results of manipulative treatment have shown this age limitation to be well founded in fact.

*Read at the Annual Meeting of the American Orthopaedic Association at Washington, May 2, 1928.

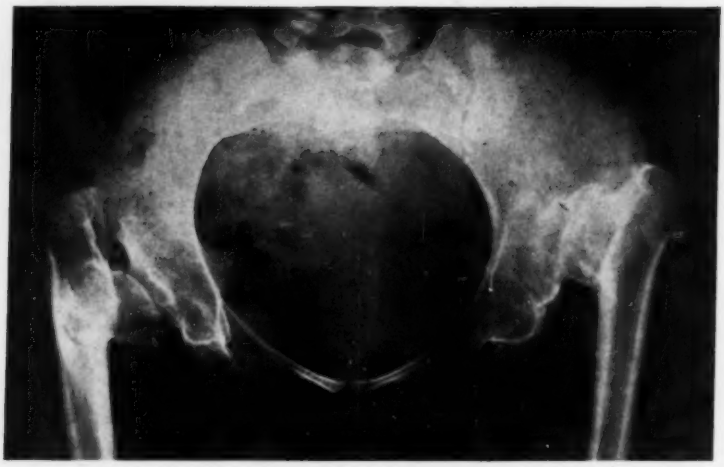

FIG. 1

Bilateral congenital dislocation of hips. (Age twenty-two.) In early childhood (age six years), both hips were reduced by manipulation. In the seventeen years following, extreme distortion of both upper femoral regions has gradually developed, and in 1923 she has reached young womanhood with extreme disability and extreme lumbar lordosis.

Very few surgeons of experience are satisfied with the results of manipulative treatment. There are very few surgeons, also, who have had much experience with the open method in the young cases. Those who have had this experience are whole-heartedly in favor of the open operation in all cases.

One fact stands out clearly in a discussion of this question,—namely, it will be by open operation, by earlier operation, and by gentler operation that the results in congenital dislocation of the hip will be improved.

The fact that congenital dislocation of the hip is an anomaly of development, unassociated with disease process of any kind, that it occurs in otherwise normal and healthy children, gives to it a peculiar character as a surgical condition. The surgeon is dealing with normal structures which are out of place. The surgical problem is simply that of reduction and retention. The object is complete anatomic and function return to normal of the maldeveloped hip.

Ten years ago the treatment of congenital dislocation of the hip had reached the stage of recognized development, wherein it was generally agreed that about half of the cases, if taken within proper age limits, could be restored to normal by a manipulative procedure. Older cases demanded operation by open incision, as did difficult cases,—that is, those in which manipulation had failed in one or more instances. The procedures used for manipulation were the Lorenz, Ridlon, Davis, and others, each operator of experience having slight variations in technique. Additionally, machine helps, such as Bradford's device or Hibbs' table were used by some as aids

FIG. 2

Double congenital dislocation of hips. (Age fifteen.) Operated on in first three years of life, both hips being reduced. At the present time there is extreme deformity of both upper femoral regions, with marked disability in both hips, in spite of the fact that his hips were reduced in early childhood. It may be assumed that the damage done by manipulation has caused this variation in the growth of his upper femoral epiphyses.

FIG. 3

Double congenital dislocation of hips. (Age twenty in 1924.) These hips were manipulated when patient was four years old in an attempt to reduce the dislocation. On the left side this was accomplished. On the right side, the hip was not reduced. During her period of bone growth, the marked changes shown in the upper ends of the femora have developed. The right hip is unstable, the left hip fairly stable. A shelf operation was done on the left side to increase stability, which was very successful.

FIG. 4-A

Double congenital dislocation of the hips. Note the marked distortion of the femoral heads.

FIG. 4-B

Reduction of dislocation in childhood, on right. Dislocation on left not reduced.

At the age of twenty a shelf operation was performed on the dislocated hip, stabilizing it and giving it good function. One year later, the other hip was operated on in same manner to give it increased stability. Although the reduced hip allowed fair function, it was not as useful to patient as the hip on which Dickson's shelf operation had been performed. At patient's request, the unstable hip was operated on in same manner.

FIG. 5

Single congenital dislocation of the hip in a girl of thirteen years, who was operated on by manipulation at the age of four years. This hip in 1925 was unstable and showed increased deformity. A shelf operation was performed at that time. In 1926 she had a good functioning hip.

to manipulation. It was generally recognized that shortness of muscles demanded cutting, and that bony deformity demanded osteotomy as aids to reduction or to retention, and here the matter rested for a few years.

Going back a little, some observations had been made on what may be called the pathologic anatomy of the condition. Allison had studied the pelvis of a child who died three months after manipulative reduction and has shown what obstacles might be encountered. His statements are based upon the study of a specimen, and on the recorded observations of Lockwood (1887), Phelps (1891), Bradford (1894), Bradford (1898), Bilhaut (1895), Adams (1895), Ochsner (1902), Wilson and Rugh (1904), summed up as follows: (Allison, N.: American Journal of Orthopaedic Surgery III, 157, October 1905).

> "From an anatomical standpoint, the obstacles to be overcome in these cases may be summarized as follows:
>
> "An acetabular cavity not of normal development.
>
> "A femoral head that is more or less irregular in shape.
>
> "A changed direction in the neck of the femur.
>
> "An adductor group of muscles too short.
>
> "All the posterior muscles with the fascia lata and the iliotibial band much shortened.
>
> "A much shortened group of pelvitrochanteric muscles.
>
> "An iliofemoral band abnormally short and strong. On this last element I wish to place especial emphasis."

In 1926 (Journal of Bone and Joint Surgery VIII, 551, July 1926.), remarks upon the success of manipulative treatment were made by Benjamin P. Farrell, Herman L. von Lackum, and Alan DeF. Smith of the New York Orthopaedic Hospital, as follows:

"1. In any large series of cases of congenital dislocation of the hip as now seen, success by closed reduction can be expected in only about fifty per cent.

"2. These results could be improved upon if more of the cases were treated early, and every effort should be made to bring this about.

"3. The other factors chiefly responsible for the failures are such that we can not hope to overcome them by any method of closed reduction.

"4. In many cases the presence of these factors can be suspected, but can be determined definitely only by open reduction.

"5. The number of open reductions in this series is too small to justify any general conclusions. We are not yet prepared to announce the results in a larger subsequent series, but we are quite certain that many of these cases, although reduced and stable, have a considerable degree of limitation of motion which has been present for a number of months.

"6. We believe that practically every congenital dislocation of the hip within a reasonable age limit can be reduced by open operation, and in that way improved.

"7. The results in this series of cases compel us to believe that a much larger percentage should be reduced by open operation than were so treated."

Herbert P. H. Galloway, who has long been an advocate of the open reduction, reported in 1926 at the meeting of the American Orthopaedic Association (Journal of Bone and Joint Surgery VIII, 539, July 1926) as follows:

"I am not advocating the adoption of the open operation by those who feel satisfied with the results they obtain by manipulation. Personally, I was driven to the open method by the distracting uncertainty and frequent failure which attended my former efforts at manipulative cure, and my results are now such that I welcome these cases instead of dreading them as I once did. I think I am justified in claiming that a method which will cure practically all children of about two years, and which has given such a large proportion of good results in patients varying from seventeen months to twenty-nine years, at least should not be entirely discredited."

On "Congenital Dislocation of the Hip", as a present-day summary of the treatment as it is now carried out in Italy, Vittorio Putti (Surgery, Gynecology and Obstetrics XLII, 449, April 1926) says:

"We are further convinced that the treatment of dislocation of the hip will in the future show results which will increase our present figures as regards successful cases. This will be easily accomplished when it becomes generally possible to begin the treatment at an earlier age than is now the case."

H. A. T. Fairbank (British Journal of Surgery X, 36, July 1922) draws the following conclusion as to treatment of congenital dislocations of the hip:

"1. If cases are sent to the surgeon sufficiently early, — *i.e.* before the end of the third year, an anatomical cure ought to be obtained by manipulative reduction in something like seventy-five per cent. of the unilateral and fifty per cent. of the bilateral cases. In the vast majority of these the function should be excellent, at any rate for many years.

"2. Of those giving an imperfect result by the manipulative method, some additional 'cures' should be obtained by a second manipulative reduction, followed in two or three weeks' time by open operation, the object of which is the making of an upper lip for the acetabulum without opening the joint. (This I regard as a much less grave operation than open reduction.)

FIG. 6-A

Double congenital dislocation of hips in a girl of thirteen years (1924). Radiogram shows extreme deformity. Over three inches of shortening. Marked lordosis. Heads of femora made a wide excursion on dorsum of ilium. This case had never been treated. In 1924 an operation was performed to stabilize left hip on dorsum of ilium. After complete recovery and regain of good function, the right hip was operated on (1926); a shelf was turned down over the head of femur on each side.

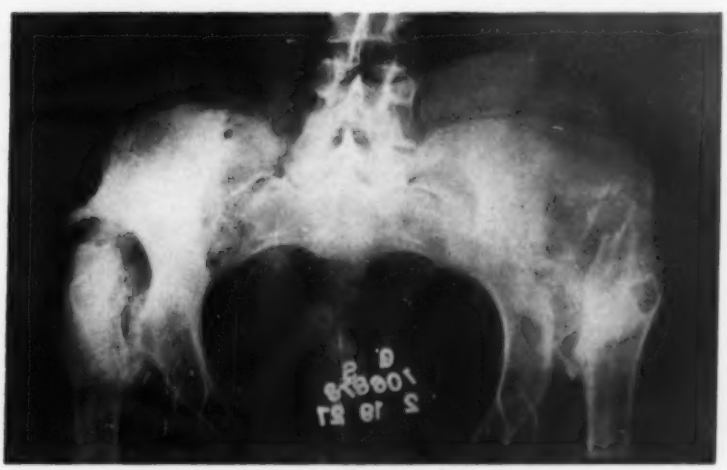

FIG. 6-B

Radiogram taken in 1927 shows an admirable result of the Dickson shelf operation.

"3. Open reduction should not be necessary in the younger cases, but is specially to be considered in those cases of the middle-age group in which manipulative reduction has proved impossible. Only in carefully selected cases should this operation be performed after the age of six years.

"4. After reduction full right-angle abduction should be maintained for a minimum of six months.

"5. Although some of the cases with an 'anterior reposition' show remarkably good functional results, we must, in the present state of our knowledge, hesitate to attribute to these patients any permanent advantage over the untreated cases.

"6. Physical treatment after removal of the plaster case, in all but the youngest patients, may exert a permanent influence on the function of the hip, but it probably has no effect on the anatomical result."

In the last ten years a recognition of the possible damage done to the growing upper femoral epiphysis by manipulation has been slowly established. This fact is of great importance. Twenty years ago it was not considered and is not sufficiently considered to-day. In consequence of this fact, it is possible to judge the result of treatment only after growth has been established.

There is a general realization that the manipulative method has promise of success in about half the cases which are well within the age limits; that older cases and difficult cases require open operation.

It is realized, also, that the growing upper end of the femur may be seriously damaged by the force applied in attempts at the time of manipulative reduction. Also, force at the time of open operation will seriously and permanently damage the growing end of the femur. In other words, the reasons for open reduction set forth in the opening paragraphs of this paper need no further substantiation.

The objective of treatment is not reduction alone, but reduction without injury. Fixation after reduction is necessary, but it should be limited to the shortest possible period of time, the chief object of treatment being a return to normal hip-joint function.

CONCLUSIONS

1. Congenital dislocations of the hip should be reduced at the earliest possible time, for two reasons:
   a. The reduction is more easily accomplished.
   b. Adaptive changes and injury to the upper femoral epiphysis are increased by function in the unreduced hip.

2. Manipulative reduction in the early years of childhood may be successful. It should be tried first. But force and resultant injury should be avoided if the hip is not easily reduced. Open operation is the better method.

We are dealing, it seems to me, with an embryological defect in congenital dislocation of the hip. We should realize that the hip is not normal at birth and that throughout the individual's life it is to be deformed. In fact, this abnormality of growth may develop into a change in the upper

end of the femur which is incompatible with normal hip function. If this be true, and I for one believe it to be true, then success or failure following any operative procedure depends to some degree upon the foreordained changes in the upper femoral region. In other words, reduction of the dislocation does not mean a perfect hip, no matter how reduction is accomplished.

Reduction (and early reduction) does mean, however, the lessening of all the secondary changes which we know follow the faulty mechanics of the unreduced hip. Force of any kind, used either in open operation or manipulative reduction, will add its influence to the development of deformity in the upper end of the femur as growth is accomplished.

NOTE: This paper was discussed with the papers presented by Dr. Swett and Dr. Gill. See page 707.—*Editor.*

OPERATION FOR OLD OR IRREDUCIBLE CONGENITAL DISLOCATION OF THE HIP*

BY A. BRUCE GILL, M.D., PHILADELPHIA, PA.

This paper is based on the study of seventy-five open operations for congenital dislocation of the hip during the period of 1919 and 1928 inclusive. The age of the patients has ranged from four years to thirty years. Twenty-seven operations have been performed on patients between the ages of four and ten years, forty between ten and twenty years, eight between twenty and thirty years. Single hips were operated on in fifty-one cases, both hips in twelve cases, making a total of sixty-three patients operated on.

SYMPTOMS BEFORE OPERATION

As far as our records show, which are not complete, pain was a prominent symptom in five out of twenty patients under ten years of age, nineteen out of thirty-three between ten and twenty years, and in all patients over twenty years of age. Ten patients, all over ten, could walk but a short distance, or only when held by the hand, and were completely disabled from work or from normal functions in life. Many who had no distinct pain tired quickly on walking.

Study of these cases shows that the older the patient gets, the more pain, the greater limp, the greater the disability which may often become total. Cases of bilateral dislocation are more disabling than unilateral.

Of those of whom we have records eighteen had had ineffective bloodless reductions or attempted reductions by reputable orthopaedic surgeons in this country and abroad. In one case the author reduced bilateral dislocations bloodlessly. One hip remained reduced and is today a normal hip functionally and anatomically. The other became redislocated and was operated on when the child was twelve years of age.

Of fifty-nine patients, thirty-five were either of foreign birth or of foreign parentage.

TYPES OF DISLOCATION

The cases operated on may be divided into three groups, which differ in the type of operation required and in the anatomical and functional results which may be obtained by operation.

The first group is the simplest. It includes those hips in which there is a shallow acetabulum with the head protruding beyond its upper margin, but without complete dislocation. At times, however, dislocation and spontaneous reduction occur in them, particularly in patients who have had infantile paralysis. These patients when young often do not complain of

*Read at the Annual Meeting of the American Orthopaedic Association at Washington, May 2, 1928.

symptoms, but as they get older they have weakness, limp, and pain after more or less use of the extremity.

In the second group are placed those cases in which there is complete dislocation, but in which by open operation the head of the femur can be replaced in the acetabulum without great force or tension. These are found only in patients under ten years of age.

The third group includes practically all cases over ten years of age in which there is upward displacement of the head from one to four inches and in which the head cannot be replaced in the original acetabulum at the time of operation or only by the use of excessive force. Some children under ten years of age are to be found in this group as age is not the only factor which prevents an easy reduction.

TECHNIQUE OF OPERATION

It was formerly our custom to apply heavy traction for a period of three to six weeks before operation. But this has been discontinued in recent years as nothing seemed to be gained by it.

An incision is made along the anterior third of the crest of the ilium to the anterior superior spine and continued in a curve downward and backward, after the method of Smith-Petersen. The tensor fasciae femoris and a portion of the gluteus medius are freed subperiosteally from the ilium. The anterior portion of the incision is carried by sharp dissection downward between the tensor fasciae femoris and the sartorius muscles, following the anterior border of the pelvis until the anterior inferior spine of the ilium is reached. Below and posterior to this point it is found that the periosteum is closely attached to the ilium where the capsule of the hip joint blends with it. The further procedures necessary from this point depend on the type of dislocation.

Type No. 1. The capsule of the hip joint is not opened. A bone flap, elliptical in shape, wide enough to cover the portion of the head of the femur projecting beyond the acetabulum, with the upper border beginning at the anterior margin of the pelvis and curving backward and downward following the contour of the acetabulum, is detached from the ilium and turned downward and the posterior part turned forward as well. This flap consists of the outer table of the ilium only. A thin-bladed osteotome is used and the flap is detached gradually and carefully throughout its entire extent and is bent downward so that it does not break off at the base. If this procedure is thus carried out, it will be found that the flap can be bent or reflected downward through an angle of more than ninety degrees, so that it lies closely in contact with the head of the femur above and behind. In detaching the flap, the osteotome is held almost parallel with the surface of the ilium, but as the upper portion of the roof of the acetabulum is approached, the osteotome is gradually brought more and more to a perpendicular with the surface of the ilium, so that it is directed inward above the roof of the acetabulum. As it penetrates deeper and deeper, the entire roof of the acetabulum is pried and bent downward. This bone flap thus has

its base at the upper inner aspect of the head of the femur and its free edge covering the upper and posterior aspect of the head. Several thick and broad wedges of bone are then removed from the crest of the ilium and are driven in deeply above the flap, wedging it down in firm contact with the head and filling in all the vacant space between it and the ilium from which it has been detached.

If this entire procedure is well done, a firmly fixed solid mass of bone is created above and behind the head of the femur which will resist any upward thrust of the femur.

The upper border of the gluteus medius and the tensor fasciae femoris muscles is then sutured to the periosteum of the crest of the ilium which has been dissected free from it before the bone wedges were removed. A few sutures are placed between the sartorius and the anterior border of the muscle flap. The skin is sutured with No. 0 twenty-day chromic catgut. If there is oozing, a rubber dam drain is inserted into the posterior angle of the wound and removed twenty-four to forty-eight hours later.

The extremity is fixed in plaster in moderate abduction. The cast is removed in four weeks and extension is applied. Active and passive motion are carried out frequently each day. Baking and massage of the hip are employed. Weight-bearing is begun gradually at the end of twelve weeks.

Type No. 2. The capsule of the hip joint is opened by cutting it with a knife or pair of scissors close to its attachment to the ilium, beginning at the inferior spine of the ilium and extending backward one and a half to two inches. Through this incision the finger can be inserted into the acetabular cavity.

The head lies in the capsular pocket above and posterior to the acetabulum. It is usually impossible to pass the finger into this pocket, owing to the constriction of the capsule about the neck of the femur, and it is usually impossible to reduce the head through this hour-glass constriction. Therefore another incision in the capsule is made, beginning about midway in the incision already made and extending at a right angle to it up to the head of the femur. Through this second incision the head can be delivered into the wound.

With scissors or knife or curved gouge the acetabular cavity is enlarged by removing from it the fibrous tissue which is found to fill it. In no instance in this series of cases, in this type of dislocation, has the acetabular cavity been found sufficiently large to hold the head of the femur. After removing the fibrous tissue and sometimes even some of the cartilage lining the acetabulum, the head of the femur can be placed in it. But even then the acetabulum is not large enough to give stability to the femur in this position. It is therefore enlarged and reenforced by turning down a bone flap from the side of the ilium and by turning down the roof of the acetabulum as described in type one. The head remains securely in the acetabulum if the femur is maintained in slight abduction. The capsule is brought up over the bone flap which has been turned down, but it cannot be sutured

FIG. 1

Type No. 1. Age twenty years. Before operation.

FIG. 2

Same as Figure 1, after operation.

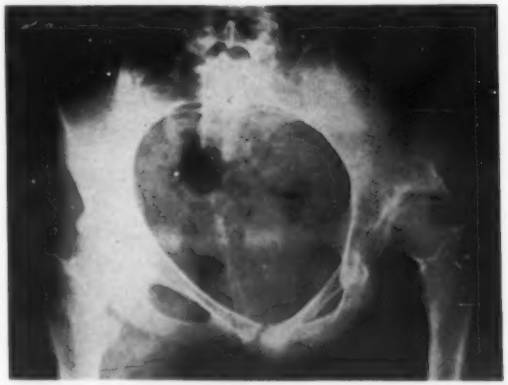

FIG. 3

Same as Figure 1, three and a half years after operation.

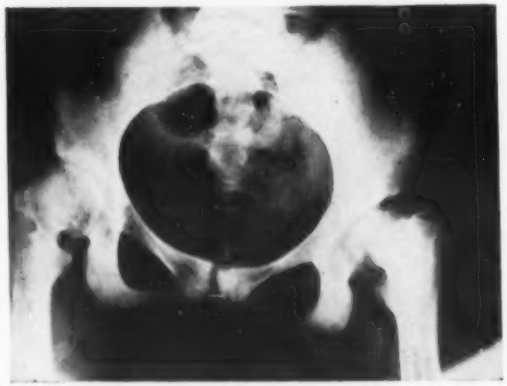

FIG. 4

Type No. 2. Reduced by open operation when eight years of age. This photograph shows condition seven years after reduction.

in any fashion. The wound is closed as described in type one, and the after-treatment is similar.

Type No. 3. The capsule is opened and the head is exposed in the manner already described in type two. In order to allow the head to go forward, it is necessary that the capsule be cut through entirely in the perpendicular incision which begins at the middle of the horizontal incision and extends upward and backward to the head of the femur. If any portion is allowed to remain encircling the neck of the femur, it is impossible to bring the head of the femur forward well into the wound.

Moderate traction is now made on the extremity to see how far down the head of the femur can be brought. This will depend, of course, largely on the age of the patient and the amount of the upward dislocation. Frequently it is found that the head can be brought to a position just below the anterior inferior spine of the ilium.

The original acetabulum is identified. It is usually found to be very small and frequently it is entirely obliterated, especially in the older cases. With a curved gouge the acetabulum is enlarged upward and backward until the head of the femur can be placed in it with moderate traction. It will remain there if the femur is slightly abducted, but the cavity cannot be made large enough to hold the head of the femur unless abduction is maintained. A bone flap, oftentimes one inch or more in width, is then turned down above and behind the head as it lies in the depression made above the original acetabulum. It is necessary to maintain the femur in abduction constantly until plaster-of-Paris is applied, lest on adduction the head should slip out and break down the bone flap. This accident has never happened in our experience.

Where the thickness of the pelvis permits above the newly constructed acetabulum, the osteotome is driven in deeply above the head of the femur, after the flap has been detached from the side of the pelvis, so that the entire newly constructed roof of the acetabulum is reflected downward and the wedge pieces of bone are driven in deeply above the roof. This makes the reconstructed acetabular roof very solid and secure and brings it into close apposition with the entire head of the femur. The wound is closed in the usual manner. The plaster cast is applied with the extremity in twenty to thirty degrees of abduction and in internal rotation.

The after-care is the same as in the preceding types. The purpose of this treatment is to secure as much mobility of the hip as possible. Six weeks in plaster cast is ample time to secure stability of the reconstructed acetabular roof. In our later cases where we have been taking larger pieces of bone from the crest of the ilium and driving them in deeply above the reflected roof of the acetabulum, we have been removing the cast at the end of four weeks. I have found there has been no tendency for the head of the femur to slip from the acetabulum and break down the reconstructed roof. We think that the earlier motion is begun, the more mobility is eventually secured. At the end of twelve weeks, the patient is allowed out of bed with crutches and begins to bear weight on the operated hip.

FIG. 5

Type No. 3. Age twelve years. Before operation.

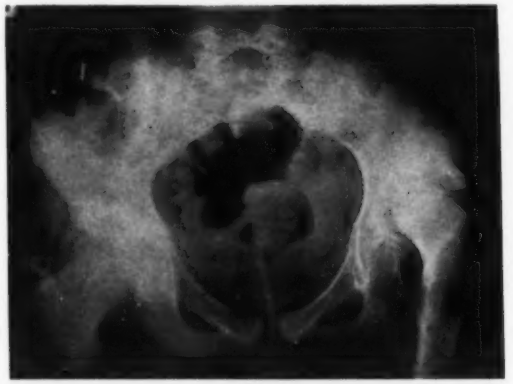

FIG. 6

Same as Figure 5, after operation.

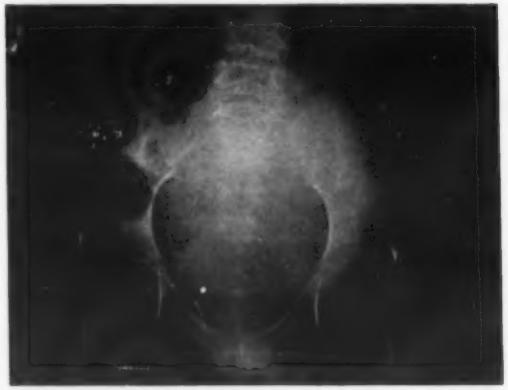

FIG. 7

Age ten years. Double dislocation. Before operation.

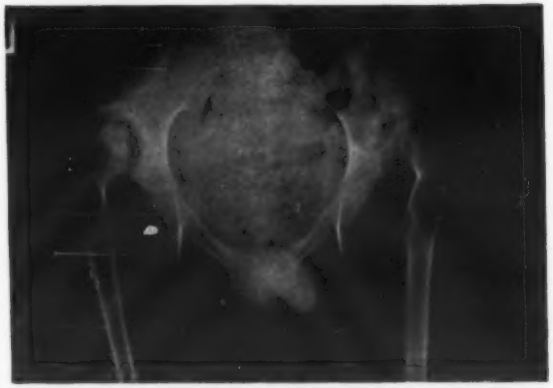

FIG. 8

Same as Figure 7, after operation on left hip.

Baking and massage, active and passive motions are employed, together with the use of apparatus in the orthopaedic gymnasium to secure increased mobility in the joint.

ABNORMALITIES AND DIFFICULTIES ENCOUNTERED IN OPERATION

1. The neck of the femur may be very short so that the head is almost sessile on the shaft. This is more apt to occur in the older cases, but it is not infrequent even in children under ten years of age.

This condition creates two difficulties in the operation. The surgeon finds it impossible to bring the head of the femur forward to the desired position along the anterior margin of the ilium or to the region of the inferior spine and the original acetabulum. Secondly, it is impossible to place the head in the newly prepared acetabulum, as the trochanter comes in contact with the side of the ilium and prevents the abduction necessary to replacement.

To overcome these difficulties, the great trochanter must be removed, the capsule must be freed from the entire circumference of the neck of the femur, and the upper end of the shaft thrust through the opened capsule as through a button-hole. This may be best done by extending the anterior part of the skin incision downward and backward to expose the shaft and trochanter of the femur. With an osteotome the muscle attached to the upper portion of the shaft,—namely, the vastus externus, is detached subperiosteally and reflected downward for about two inches, or even more in adults. The trochanter is then removed with the osteotome. The attachment of the capsule about the neck of the femur is divided with scissors or the knife. The femur is thrust through this opening and the head with ease enters the prepared acetabulum and remains there firmly on abduction of the femur.

The capsule now grasps the upper end of the femur just below the original site of the trochanter, and we believe it becomes attached here where the bone has been denuded of its periosteum.

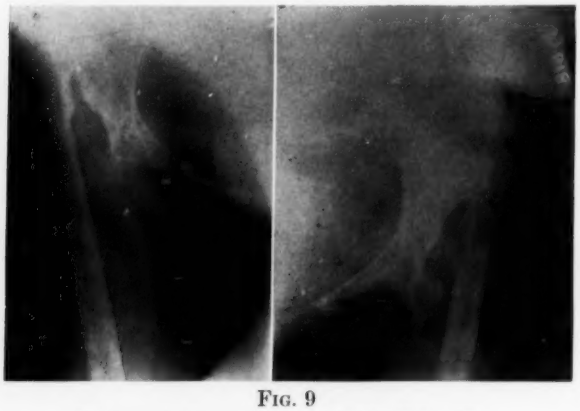

FIG. 9
Age twenty-four years. Double dislocation.

The great trochanter remains on the outside of the capsule and drops down against the denuded shaft as the femur is abducted. The detached muscle with the periosteum is now sutured over and to the trochanter, holding it firmly against the side of the femur where it becomes attached eventually by bony union.

2. Deformities of the head of the femur are the rule rather than the exception. Even in children under ten years of age it is remarkable how seldom it is of normal shape and formation.

It may be mushroom-shaped, or conical, or markedly flattened on the side where it has been resting against the side of the pelvis, or of very irregular contour with wart-like excrescences.

It may be only partially covered with cartilage which may form islands here and there on the head. The cartilage at times appears to be very loosely attached around the margin of the head and may be torn entirely loose if violence is used in trying to force a reduction. At all times it seems to be of delicate structure and is easily indented, as,—*e.g.*, by the edge of the acetabulum if the head rests there under too much tension. This constitutes one reason why only moderate force in traction is used in placing the head in the new socket. In one or two of the writer's earliest cases operated on, the cartilage was torn from the head on trying to pry it into the acetabulum and bony ankylosis resulted.

The deformity of the head is frequently so marked that one might wonder that any motion would be possible in the reconstructed hip. But we have great confidence in the wonders that nature works in accordance with the laws observed by Wolff and Roux.

3. The ligamentum teres is elongated, relaxed and atrophic. It is valueless and is removed, as it may fill up the space in the newly formed acetabulum and prevent the secure entrance of the head.

4. False acetabula may be present in the older cases, oftentimes remarkably well developed and sufficient to hold the entire head. In several of the writer's earlier cases, he was content to allow the head to remain in the false acetabulum and to deepen this acetabulum by gouging it out. The objection to this operation is that it leaves the head displaced upward and

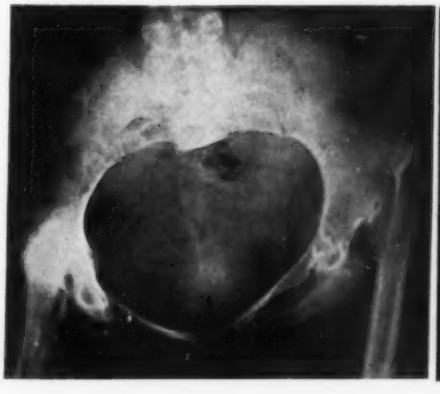

FIG. 10

Same as Figure 9, after forcible open reduction. Bony ankylosis. Corrected later by arthroplasty.

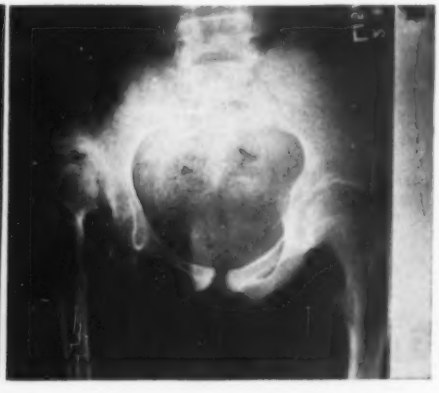

FIG. 11

Age twelve years. The only case in which infection occurred following operation. This photograph shows final result a year after healing.

backward and there is certain risk of after-pain in such cases. Patients sometimes with very good false acetabula suffer great pain, probably because of the arthritic process going on in such acetabula. Another cause of pain, and possibly a contributing cause of the arthritis, is the fact that even in a large well formed acetabulum the head moves too freely in it and can be drawn down as much as a half inch. The head is not at all times in normal relation with such a socket. In his more recent cases the author has removed the entire false acetabulum with its floor and brought it downward and forward as near as possible to the site of the original acetabulum and has used a portion of the roof in the bone flap which is turned down over and behind the head of the femur. This improves the position of the femur and makes a more secure acetabulum.

5. Version of the neck which has been talked about by so many orthopaedic surgeons has never presented any difficulties in operation, and in no instance has the writer been obliged to operate to correct this condition.

6. In old cases of upward dislocation of three inches and more, it may be impossible to bring the head of the femur below the inferior spine of the ilium. In such cases it is brought forward to the border of the pelvis, where with a gouge a small depression is made on the side of the pelvis sufficiently large to keep the head of the femur from slipping upward and backward when the femur is maintained in abduction. Sometimes the pelvis has been found to be so thin at this point that the depression could not be made any deeper than about three-eighths of an inch; but even in such cases a complete, stable acetabulum may be reconstructed by the methods described. It does not require a very deep depression in the acetabulum to maintain the head when the femur is well abducted, and the bone flap which may be turned down above and behind the head of the femur may be of any size necessary.

BILATERAL DISLOCATIONS

When we are confronted with dislocations of both hips there may be no choice as to which hip is operated on first. At other times, greater pain and disability in one hip cause us to operate upon it first. Operation on the other one is never done until sufficient mobility is secured in the first, as we cannot run any risk of making two stiff hips.

RESULTS

1. Stability. A strong, stable hip has been secured in every instance. An acetabulum large enough and strong enough for weight-bearing has always resulted. There has never been any redislocation. Under the influence of normal function, nature smooths and moulds the new acetabulum to fit the head. It seems probable in this type of operation that stability can be obtained in practically all cases.

2. Mobility. In type one there is no loss of mobility, which both before and after operation is practically normal in all directions. Type two

is also very favorable for good mobility. Flexion of the hip has ranged from forty-five to beyond ninety degrees. Rotation also is good or even normal, and there is always sufficient abduction for good function. Type three presents the most difficult cases. There have been three cases of ankylosis, all of which occurred among the earlier operations which were done. They were due, I believe, to either too much traumatism of the cartilage of the head in reduction or reduction under so much tension that the cartilage disappeared from pressure. Motion in other cases has ranged from twenty degrees to beyond ninety degrees. Abnormality in the shape of the head of the femur probably contributes to lessening the mobility. Where there has been some motion present at the end of three or four months following operation, it has been our experience that this motion improves with function. Limitation of motion is due, for certain periods after operation, to muscle spasm, as it has been found that under anaesthesia there may be fairly good motion in the joint which is held more or less fixed when the patient is conscious.

One patient operated on in 1922, when twenty-four years of age, with three and a half inches upward displacement of the head of the femur, had a bony ankylosis following operation. At the time of operation the original acetabulum was enlarged and the head of the femur was forced into it. The cartilage of the head was displaced. Later an arthroplasty has been done on this hip and the patient at the present time has a stable painless hip with good function. So that bony ankylosis is not necessarily an irremediable final result.

Being assured of stability in all cases, our efforts are directed toward improving our results as to mobility.

3. Pain. Only two patients in the group of cases operated on have had pain persisting for more than a brief period after operation, and this has been but slight. The stability of the hip evidently removes the cause of pain from which they suffered.

4. Function. The ability of these patients to lead a more or less normal life is largely improved by operation. Patients who formerly were unable to walk more than a short distance, who were unable to do any work either at home or in earning a livelihood, have been able to return to practically a normal existence. One girl who was badly disabled has since walked as much as thirteen miles in a day, has been married, is raising a family, and doing all her housework.

5. Accidents attending operation. There have been no fatalities. The operation is not a shocking one and patients do not suffer very severe pain after operation.

But one case of infection has occurred in these seventy-five cases. During the operation the bone flap which was being turned down from the side of the pelvis fell upon the floor. It was sterilized by boiling and used as the roof of the new acetabulum. About six days later the patient began to develop fever and eventually showed evidence of infection about the hip. A large part of the ilium became involved in the osteomyelitis. She

had a large intrapelvic abscess. To secure good drainage of the pelvis and the regions about the hip, a section of the ilium, about one inch wide, beginning about one inch below the anterior superior spine and extending back horizontally for about four inches, was removed. After this the wound healed promptly. It has remained healed for a year and a half. New bone has been thrown out about the head of the femur, which remained in the position in which it was placed at the time of operation. At the present time there is a very competent acetabulum containing the head of the femur and the patient has fair motion in her hip and is without pain. In this case the condition which looked rather threatening has resulted in a very serviceable hip. The writer is rather inclined to ascribe the infection to a hematogenous one occurring after operation, owing to the fact that fever began to manifest itself six days after the operation.

CONCLUSION

These methods of operation have been developed by the author during his experience of the past ten years, beginning at a time when, as far as he knows, he had no outside help except the suggestion of Dr. Albee that a wedge from the tibia might be used to hold down and strengthen the upper portion of the acetabulum. To this surgeon modern bone plastic surgery owes largely its inspiration.

Stability of the hip is assured in all cases. Freedom from pain is also almost constant. Mobility is always good in type one, usually satisfactory in type two, and quite variable in type three. The author's efforts are still being directed to improvement in the technique of operation and in the after-care to secure better and more uniform function in this last group of cases. He believes that the greater hindrances to motion lie in the soft structures of the joint and about it, rather than in the bone elements. The latter under the influence of Wolff's law are transformed more and more toward the normal, though they may be far removed from this in the beginning.

These operations are designed to relieve a group of patients who are already very seriously disabled or promise to become so as they grow older. An arthrodesis, or ankylosis, of the hip, which is the worst surgical result that may be obtained in these cases is a vast improvement over the preceding condition of the patient, as weakness, tire, and pain are removed. A patient with a stiff hip is able to work hard and to enjoy many pleasures in life. Her most serious handicap may be an inability to lace her shoe. Satisfactory motion, which may be obtained in the great majority of cases, may from this point of view be looked upon as an added blessing. But good motion in the other hip is, of course, essential. The author has been obliged at times to defer operation on the second hip in cases of bilateral dislocation because good motion has not been obtained in the one already operated on. For this reason, if for no other, it is desirable to press our efforts in securing satisfactory mobility in all cases, so that one may be able to guarantee it as well as stability.

The author attempts bloodless reduction on all cases under six years of age. If he is unable to secure it without the use of severe violence he does not hesitate to advise open operation. These cases fall into group one or group two, in which eminently satisfactory results may be secured.

If the hip can be replaced bloodlessly but, because of the shallowness and weakness of the acetabulum, shows a tendency to relapse after six months in plaster as the extremity is gradually brought down to a normal position, open operation is advised. These cases belong in group one. If relapse occurs as late as two or three years after bloodless reduction, open operation should be done as in type one. It seems to the author needless and unwise to subject these patients to many months and even years of plaster treatment when a splendid hip may be secured in three months by open operation.

When open operation is necessary, the earlier it is done the better. The younger the patient, the better the result. Eighteen of the author's cases had had futile bloodless reductions.

The orthopaedic surgeon will add tremendously to his armamentarium, if he will add open methods of reduction to his bloodless method. He will then bring his cures from an average of sixty-five per cent., approximately, up to one hundred per cent. in all patients under six years of age and he will be able to afford some measure of relief to those older cases, which until within recent years were regarded by all as hopeless.

The author has not tried the Lorenz bifurcation operation, as he has believed it sounder surgery to continue his efforts along the lines outlined in this paper.

Experience gained in operations upon congenital dislocation has been of great assistance in cases of pathological dislocation which present much the same features and difficulties as the difficult cases of congenital dislocation.

DISCUSSION

Mr. Harry Platt, Manchester, England: I feel considerable diffidence in following Dr. Ridlon with his lifetime of experience. This subject will probably provide opportunities for debate for the next twenty years. At the present time there is a growing dissatisfaction with the anatomical results of closed reduction, and we appear to be on the eve of a revival of the open operation in young children. A good many open operations have been done in recent years, but we must recognize that we shall have to wait perhaps another twenty years before we can show the end results. In England congenital dislocation of the hip is a comparatively rare deformity and no one man ordinarily deals with a great many cases himself, except, of course, our great teacher, Sir Robert Jones, whose clinical material has always been unique.

Dr. Allison has stated that in many of the unreduced dislocations in older children or adults the hips gave very little trouble. I have also been impressed with the fact that often it is not the unreduced, untreated hip that is troublesome, but the subluxated hip on the so called sound side. I have seen some half-dozen patients who have worked hard up to the age of forty with an unreduced congenital dislocation of one hip and in whom a subluxated hip on the other side has become painful and the seat of arthritis under the influence of wear and tear.

Some of us in England have lately been tempted to try the open operation at an earlier age. My own feeling is that in a dislocation in an older child or adolescent, we

should always try hard to bring the femoral head into contact with the acetabulum. The construction of the shelf over a dislocated head to my mind falls short of the ideal. I do not think the bifurcation osteotomy of Bayer and Lorenz has received the support that it deserved. If one examines radiograms of the older, unreduced hips, one sees quite often an attempt on the part of the lesser trochanter to make contact, as it were, with the site of the primitive acetabulum. This has gone far to stabilize the articulation and is the rationale of the bifurcation osteotomy. In unilateral dislocations the osteotomy, in my hands, has given very satisfactory results. In the few bilateral dislocations in which I have done the operation, the results have been disappointing.

Dr. Robert Soutter, Boston, Mass.: It is the difficult cases of congenital dislocation of the hip that have troubled us a great deal and the difficult cases are: those with very tough muscles, those in which the head must go very far to reach the acetabulum, those that have some obstruction preventing the entrance of the head into the acetabulum, those with bony defects, and, of course, the combination of these four conditions.

A good deal may be said as to the standardization of the method of reduction. I do not think it makes any difference whether you use an open method or what closed method you use, so long as you know what you are working at.

When a patient is given ether, and a manipulation is done, there should be reasonable assurance that some sort of result will be obtained for the patient. To have a satisfactory result, it is not only necessary to put the head in the acetabulum but when the head is put in the acetabulum, it should be manipulated after it is reduced so that it is put in a position in which it is reasonably safe and will not come out easily. But that is not all. One of the very steady positions after reduction is that in which, after the head is placed into the acetabulum, the femur is flexed slightly more than ninety degrees and abducted slightly more than ninety degrees. In this position, the head is less apt to slip upward and less apt to slip backward. When this is accomplished, it is not a satisfactory reduction unless the head can be felt to click or jump in, as it is reduced, or to click or jump out when it is redislocated. Sometimes I have reduced a hip and I have not been able to tell the exact moment the hip went out when thrown out. That head should be manipulated in all positions with inward and with outward rotation until it will click in and click out. Then we have a satisfactory reduction. When the patient has been put through this sort of reduction and when it is impossible to reduce the hip with one of the tried methods, there is going to be a lot of disability later on. This disability comes from the posterior position of the hip and it also comes from the fact that there is no bony leverage to hold the head when weight-bearing. We have been using the shelf operation very successfully for that type of case. It is very important to put the hip as far forward as we can to prevent lordosis. If an anterior position can be obtained, this is a desirable position when a shelf operation is anticipated. If instead of using a shelf, we can get our bony leverage by putting the head directly into the acetabulum, as suggested by Dr. Swett, this is going to be a great help. The fact that it is possible to do that operation without having the head lose its blood supply is quite important.

As to the changes that appear in congenital dislocation of the hip long after operation, it seems to me that these changes are going to come in a certain proportion of cases, no matter what method of treatment has been attempted. At least this seems to be the general impression. We all know of simple dislocations that have been reduced without any effort when the child was very small, and years afterward bony changes have taken place. Undoubtedly these changes are due to some congenital condition, a condition very similar to that which we see in other congenital deformities. Since this occurs in cases that have had practically no trauma, and in very simple reduction, it is very probable that it is a pathological change which we must expect in a certain number of cases and we should not lay them up against the method of operation.

As to an open operation versus closed, Dr. Putti, in 2,550 cases, found five per cent. irreducible. What shall be done with these is what we are considering today. As to the comparison of cures today and twenty-five years ago, his results have been about eighty per cent. cures in single cases and sixty-five per cent. cures in double cases.

In the paper I published with Dr. Lovett in 1924, considering 355 operations, we reported eighty-three per cent. of success in one count and seventy-three per cent. of success in another.

We should bend our efforts to treat all cases at an early age. If this can be done, we will eliminate almost all of the difficult types of cases, and even greater percentage of cures may be expected.

Dr. B. P. Farrell, New York, N. Y.: There is about as much discrepancy of opinion as there are hips. Some always think it is a settled question that the results are questionable. I am going to agree with Dr. Allison that the results in congenital hips throughout the country are far from satisfactory and that the percentage of cures is very low, much too low for a condition that is as common as congenital hips. We have never been able to get anywhere near ninety per cent., or eighty per cent. even, in functional results. Our anatomical results are very much less. I think the report we made two years ago gave something around fifty-five or fifty-eight per cent. good functional results. As one listens to the men who are getting seventy, eighty, ninety per cent. good results in congenital hips I feel there may be something wrong with our methods; to date I do not know what it is.

Dr. Swett's paper interested me very much. Dr. Hey Groves reported last year a similar operation in an adult performed five years ago and he was very much pleased with the result. In place of two oblique osteotomies he did a transverse osteotomy and put a bone peg in the medullary cavity. Personally I am rapidly coming to the conclusion that open operation is much preferable to manipulation unless the reduction can be done with very little trauma. Open operation is simple and can be done very quickly and certainly with much less trauma and damage to the hip joint unless manipulation is very easy, and as you know a very large percentage of the cases are not.

Dr. David Silver, Pittsburgh, Pa.: The lack of improvement in the results of the treatment of congenital dislocation of the hip as shown by a study of statistics for the past twenty-five years, which Dr. Allison reports, is most important if these statistics represent correctly the general experience. The analysis of the causes of such a lack of improvement should prove of the greatest value in pointing the way to a possible future gain. One very simple reason suggests itself. May it not be due very largely to the fact that, owing to the intensive study of the subject carried out in the early years of this century at a time when the clinical material available was unusually rich, the problem was worked out so well that but little advance is to be expected along this line?

Hope of future improvement, Dr. Allison said, if I understand him correctly, is to be looked for in open operation. This statment appears to me to be absolutely wrong. *Hope of future improvement lies in early recognition.* Thus reduction is made possible before or very soon after the beginning of weight-bearing, that is, at an age when structural adaptation is present only in slight degree; hence, reduction can be carried out without traumatism, harmful muscular tension is absent, and the possibility of securing a perfect anatomical joint through early growth is greatest. The early teaching, of which the influence unfortunately still remains, was that treatment must be delayed until sphincter control had been acquired. This is unnecessary as well as unwise. The Feiss brace makes it possible to care for an infant entirely satisfactorily, and with slight modification the hip may be immobilized in any desired position. Since structural adaptation becomes increasingly greater as the child grows, and hence the degree of function to be hoped for becomes correspondingly less, whatever the method of treatment used, would it not be wiser for us to devote less time to the discussion of the relative merits of the closed and open methods and concentrate our energies on efforts to assure diagnosis as early as possible? This would mean a campaign of education, both of ourselves and our colleagues, among the latter chiefly the pediatricians and the obstetricians. Orthopaedic surgeons should make it a routine practice to verify the position of the femoral heads in all infants and little children presented for examination; and not only this but infants who have been examined early should be reexamined around the walking period if opportunity offers. All children born in hospitals should have the benefit of

examination by the hospital orthopaedic surgeon as a part of the regular routine. Furthermore, an effort should be made to secure the cooperation of pediatricians and obstetricians generally to the end that they accustom themselves to carry out this detail of examination.

While closed reduction, when its technique is mastered, will give the highest possible percentage of cures if treatment is instituted during the first year or two of life, this is obviously too much to expect when it is called upon to meet the marked changes present in neglected cases. The value of different open procedures in improving cases of this group appears now rather definitely established, yet it would still seem safer to plan only for improvement and not to hope for a large percentage of perfect results. Our Association is fortunate in having among its members a goodly number of excellent surgeons and it is only natural that men thus skilled should have a decided bias toward open operation. It is best to recognize this frankly, lest we be unduly influenced by their opinions and be led to give open operation too prominent a place.

Much is said about the treatment of the irreducible dislocation, without any very clear definition of what is meant by the term. May I suggest that it be applied to those cases in which the displacement is so great that the head either cannot be brought down with safety to the level of the socket or, having been so brought down, the resulting tension on the tissues after reduction is so great as to seriously impair joint function. Any plan for the improvement of irreducible dislocation must be devised so as to correct or prevent the following factors in disability:—

1. Distortion of the trunk, due to the posterior-displacement of the head.
2. Instability.
3. Excessive muscular tension; and
4. Deformation of the head, resulting from lack of conformity of the surface of the ilium to the contour of the head.

The best procedure is not necessarily the one which, when carried out by a particularly skillful surgeon, gives the most nearly anatomically perfect joint, as judged by the radiogram, but that one which, in the hands of the average orthopaedic surgeon and with the greatest safety to the patient, can be relied upon to give the most generally useful hip. The unsightly lordosis of the bilateral dislocations is absent, as is well known, in the anterior type and hence, transposition of the head under the anterior superior spine was early advocated when reduction was impossible. Stability can now be assured by the formation of a secondary socket with a good superior and posterior rim. A properly shaped socket is also the most efficient safeguard against deformation of the head. Finally, there is no increase in muscular tension when transposition is used.

The method which has been followed recently at the Alleghany General Hospital in bilateral cases and which seems to best meet these indications is the following: Treatment is divided into two stages. The head is first transposed, placed well under the anterior superior spine in moderate abduction, hyperextension and outward rotation, and is then fixed in this position in a spica. This is left *in situ* for about ten days and then bivalved, preparatory to open operation. At operation the head is exposed in the usual manner, the superior and posterior surfaces of that portion of the capsule covering the head carefully freshened, a depression corresponding in shape to the contour of the head made through the outer table at the point where the head is resting, and a sufficient superior and posterior rim formed. The transposition of the head brings it into the most favorable possible position for operation and makes of it a relatively simple procedure, so that both hips may ordinarily be operated upon at the same time. For the irreducible dislocation this method combines, therefore, what experience has shown is the best of both the closed and the open procedures.

Our experience with the few bilateral cases treated by this method leads us to feel that it is not only the simplest and safest one, but that it promises the best functional results. As far as its use in unilateral cases is concerned, we have had no experience as yet, but we feel it will meet the indications proportionately well, since the moderate

shortening incident to transposition is of little moment when the other sources of disability are corrected.

Dr. J. Torrance Rugh, Philadelphia, Pa.: There are two points that have been brought out very strongly in the discussion. One is our failure to define what we mean by cure in these cases. The other is, when can a cure be said to be obtained in these cases? That has not been shown in the report Dr. Allison has made, and Dr. Ridlon did not say. We have no definition of what constitutes a cure in cases of congenital dislocation.

The second point I want to make is this: It has been shown that different methods of treatment have been very successfully carried out by different operators. The men doing this work have had no special interest in following out the results of the operative work. It seems to me we are losing sight of the fundamental facts that Dr. Allison recognizes. We are not dealing with a normal structure. No matter what operation is done, we are still dealing with a pathologic structure, and we may expect changes from function. We cannot speak in terms of normal function or normal results in a short time, because of the abnormality of the structures with which we are dealing.

AN ADDITIONAL REPORT UPON AN OPERATION FOR STABILIZING PARALYTIC HIPS*

BY FRANK D. DICKSON, M.D., KANSAS CITY, MISSOURI

In 1927 I reported an operation for stabilizing paralytic hips. In this report, a procedure was described by the use of which it was felt that some of the disability which results from paralysis of the gluteus maximus and medius muscles could be overcome. It is still our belief that the procedure is a useful one, and for this reason, it is again brought to your attention for discussion and criticism.

The importance of hip-joint stability in efficient and comfortable locomotion is so well recognized that it needs no discussion nor elaboration. Such stability depends upon the coordinated action of the muscles controlling the hip joint, and upon their functioning in such a way as to steady the pelvis upon the head of the femur. If, as the result of infantile paralysis, a state of muscle unbalance exists, we have a hip joint which is either so unstable as to render it incapable of weight-bearing, or one which is able to sustain the body weight only when the center of gravity is balanced over it in a certain position. In the first condition, we have a flail hip which is useful only when strongly braced and aided by crutches. In the second condition, we have a hip joint which can be given momentary stability by dropping the opposite hip, or by throwing the body toward the affected side. Such a hip joint is distinctly unreliable and readily gives way, while the movements necessary to bring the center of gravity over the supporting leg produce the unsightly lurching gait which is so characteristic.

An additional disadvantage which results from an unstable hip in cases of anterior poliomyelitis is the added stress thrown upon the knee joint. In walking with an unstable hip, the knee joint is called upon to take on an unusual amount of strain because of the abnormal gait; this is often more than it is capable of assuming, as frequently its supporting muscles are impaired. As a result, a knee which would be capable of weight-bearing, becomes incapable of functioning properly with the added burden of the unstable hip to overcome.

In attempting to estimate the relative importance of the various muscles of the hip joint, so far as giving stability to the joint is concerned, it has been our experience and that of other observers, that the gluteus maximus, gluteus medius, and tensor fasciae femoris seem to be chiefly responsible for stabilizing the pelvis upon the head of the femur. Paralysis of all these muscles results in a flail hip; paralysis of the gluteus maximus or gluteus medius causes serious interference with stability. Considering these

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three muscles, we find that the gluteus maximus is chiefly an extensor of the hip joint, but through its insertion into the fascia lata, it also serves to steady the pelvis on the head of the femur. The gluteus medius is an abductor of the hip joint, but its most important function is the steadying of the pelvis on the head of the femur. The tensor fasciae femoris is usually considered to be chiefly a flexor of the hip. It is, however, an important abductor and certainly in the erect position at least, has a very important part in steadying the pelvis upon the head of the femur, acting through the iliotibial band. It would seem, then, that apart from the chief individual action of these three muscles, we must consider them collectively as stabilizers of the pelvis on the head of the femur. As the predominating action of these muscles, aside from the flexion action of the tensor fasciae femoris, is that of abducting and extending the hip joint, these movements must be essential to such a steadying of the pelvis on the head of the femur; in other words, to hip-joint stability. It should, therefore, follow that to restore stability to an unstable hip, it is necessary to supply these movements if lacking, or reenforce them if weak.

The gluteus maximus and medius are muscles frequently paralyzed in anterior poliomyelitis, so that instability of the hip joint is generally due to paralysis of one or both of these, most frequently the gluteus medius. The tensor fasciae femoris, on the other hand, is only infrequently paralyzed. This fact, together with the close association in function between this muscle and the glutei, makes it reasonable to consider using the tensor fasciae femoris to replace, in part at least, these muscles when weakened or lost. In its normal position, the tensor fasciae femoris acts as an abductor and stabilizer of the hip, and, as it lies anterior to the axis of the hip joint, as a flexor of this joint. It seems that if, in an unstable hip, the tensor fasciae femoris could be changed from an abductor and flexor into an abductor and extensor, an increase in hip stability should result. This could be accomplished by transplanting the origin of the tensor fasciae femoris from its position just external to the anterior superior spine to a new position on the crest of the ilium in the vicinity of the posterior superior spine, thus bringing the muscle posterior to the axis of the hip joint, in which position it should act as an extensor of the hip instead of a flexor, and so add to the power of this movement which seems essential to hip-joint stability.

This procedure was carried out and proved to be feasible. The results on the whole have been satisfactory. We feel that a definite improvement in gait has been secured in the majority of cases. There has been an increase in the stability of the hip in weight-bearing by observation and according to the statement of the patients themselves. This, so far as we can determine, is due largely to an increase in the extending and abducting power. Many patients who were unable, when lying prone to elevate the leg from the examining table, could do so to a very satisfactory degree after the operation, and in these cases, abduction was definitely stronger.

We believe that stabilizing the hip joint in this way has, in a number of

instances, improved the power in the hamstring muscles. In examining cases with an unstable hip joint, it has been observed that if the head of the femur was held firmly in the acetabulum, by pressing forward and upward with the palm of the hand against the trochanter, and knee flexion carried out, there seemed to be definitely more power in the weakened hamstring muscles. At times it was possible for a patient to actively flex the knee against gravity, this movement being impossible without such stabilizing of the hip joint. We have explained this effect as being due to the elimination of the upward slipping of the head of the femur which is demonstrable in all unstable hips, thus maintaining the maximum length between the origin and insertion of the hamstring muscles. This enables these muscles to utilize their full range of contraction, and eliminates a waste of force due to "lost motion". The transplantation of the tensor fasciae femoris posteriorly seems to have the same effect in a certain number of cases. We have felt that possibly some of the increased extensor power observed in postoperative cases, with the knee extended at least, may be due to an increased efficiency in the hamstring muscles which are extensors of the hip when knee flexion is prevented. Whether or not there is an improvement in knee control *per se*, certainly any improvement in the hip stability has a beneficial effect upon the knee joint by decreasing the strain it is called upon to bear.

A word should be said about paralysis of the glutei associated with flexion contracture of the hip joint. It has been our practice in such cases to transplant the origin of the tensor fasciae femoris posteriorly and later, if necessary, do a modified Soutter operation. In only severe cases has this been necessary. In one case with a marked coxa valga, a subtrochanteric osteotomy was necessary to bring the hip into adduction.

It was stated in the preliminary report that in some cases the operation was done even when little or no power was present in the tensor fasciae femoris. Our thought was that a strong fascial band placed posterior to the axis of the hip joint might have a definite stabilizing effect. At present, we do not feel thoroughly convinced as to the usefulness of this and temporarily at least have ceased to use this procedure.

In attempting to tabulate the results of this operation, we have encountered difficulties in arriving at a satisfactory basis for estimating improvement, as many of these cases have had other operative procedures carried out on the same extremity on which the transplantation of the tensor fasciae femoris had been done. Furthermore, the failure to eliminate the limp cannot be construed as failure to secure increased stability, as many cases have sufficient shortening of the limb to cause some limp even with a stable hip. We feel, however, that in these cases in which the ability to extend and abduct the hip has been restored or improved, and in which a definite improvement in gait has been secured, it is fair to ascribe the improvement to this operation.

The total number of cases operated upon is forty-six. Of these, thirty-two have been under sufficiently close observation to enable us to be

sure of their condition following operation. Of these, ten have had the limp eliminated or greatly improved; fourteen have had a definite improvement in stability of the hip, but with a definite limp remaining; eight have been failures in that we feel that no more improvement has resulted from this operation than could be gained by overcoming the hip-joint flexion present. All the failures were cases in which we used a weak or paralyzed tensor fasciae femoris.

DISCUSSION

Dr. DeForest P. Willard, Philadelphia, Pa.: Dr. Dickson is about the only man who can speak with any sufficient experience and authority on this question. When he talked to me about it last summer it seemed a very sensible operation. As the tensor fasciae femoris is one of the muscles that stabilizes the hip joint and is one of the muscles least often paralyzed in poliomyelitis, it could stabilize the hip even if it could not take on all the functions of the gluteal group. The operation seemed very easy to do and it could not damage the child by removing the tensor fasciae femoris from its normal attachment and placing it backward.

The one difficulty that we had in the operation was in getting the new attachment close to the posterior spine. We found in two cases that the muscle was quite short and we had to place it close down to the side of the ilium, so we made that attachment. But the whole idea is to get the tensor fasciae femoris directly over the trochanter and over the hip joint itself.

In all our cases, four in number so far, we took those partly paralyzed from infantile where the gluteals were gone and the tensor fasciae femoris was good and the hip joint unstable. Dr. Dickson said he took a paralyzed fascia femoris and transplanted it. I believe his results were not satisfactory. Our after-results are over such a short period that we are not able to say much as yet. These four patients are walking and unquestionably they are walking with less limp. The hips are stable. The thing that has impressed me is that the patients themselves have gained confidence in their ability to walk. Their gait has improved, they are willing to step out and willing to try to walk. Our little experience shows that it is certainly worth while going ahead with.

DOES PERIOSTEUM FORM BONE?

BY EMIL S. GEIST, M.D., F.A.C.S., MINNEAPOLIS, MINN.

The following case seems evidence to lead one to suppose that it does.

CASE REPORT

G. H., Case No. 10007. Male, age thirty-two, salesman. Injury, May 29, 1925, auto accident.

Diagnosis: (a) Fracture of the lower third of left humerus.
(b) Fracture, comminuted, left elbow.
(c) Fracture of left wrist.

Treatment: Left elbow; copper wiring of dissociated fragments comprising the upper end of the left ulna.
Left wrist; manipulation and splint.
Left humerus; on account of the two joint fractures present in this same arm (elbow and wrist), the question of accurate opposition of the fractured ends seemed secondary. Extension and fixation were employed.

Result: Left elbow; no pain—sixty-five degrees useful motion.
Left wrist; no pain—normal motion.
Left humerus; clinically, no deformity.

Comment: This case is presented solely because the new bone as viewed by roentgenograms (Figs. 1 to 8) seems to be periosteal in origin. Even late x-rays (Figs. 4 and 5) show no apparent participation of the bone ends in the healing process.

FIG. 1
Two months after injury.

FIG. 2
Four months after injury.

FIG. 3
Five months after injury.

FIG. 4
Seven months after injury.

FIG. 5
Nine months after injury.

FIG. 6
Fourteen months after injury.

FIG. 7
Nineteen months after injury.

FIG. 8
Twenty-eight months after injury.

BONE-KEY OPERATION FOR FUSION OF SACRO-ILIAC JOINT

BY A. D. LAFERTÉ, M.D., DETROIT, MICH.

During the past few years there have been several operative procedures reported to secure fusion of the sacro-iliac joint. These operations are all undoubtedly efficient, but seem rather mutilating, as they entail either a complicated displacement of soft tissues and bone, or a severing of the posterior sacro-iliac ligament, a structure which, in the opinion of the writer, should be preserved to carry on its very important function until fusion has taken place.

An operation, with case history, is presented herewith, which involves no destruction of the tissues about the joint and which does not materially weaken the posterior sacro-iliac ligament.

The patient, Mr. A., referred by Dr. G. M. was admitted to Harper Hospital in September 1915. The family and past histories were negative. Eight months before, a dull pain appeared in the right sacro-iliac region, becoming gradually worse and radiating down the thigh posteriorly. Coincident with this, the patient began to limp. He was then confined to bed. The patient had night sweats, and an afternoon temperature of about one degree. He lost between thirty and forty pounds in weight. The von Pirquet was positive. It was very difficult to examine the patient because of pain on slightest movement; tenderness over right sacro-iliac joint; excruciating pain when pressure was applied to both ilia.

A diagnosis was made of tuberculosis of the right sacro-iliac joint. This was confirmed by the x-ray. A cast was applied two days later which gave considerable relief, and the patient was sent home with instructions to remain in bed. He was told that this confinement would last for at least one year. He was seen off and on at home until March 1916, when he became restless and wanted to be about. Experimental operation was discussed, and the patient was advised that if it were performed and were successful, it would cut down the duration of the confinement to bed. If unsuccessful, however, it would not lengthen the course of the disease, and the only drawback would be the inconvenience of the operation. The patient readily consented to operation which was performed on March 3, 1916.

A curved incision, about five inches in length, was made, beginning above the posterior superior spine and extending obliquely downward over the joint. The soft tissues were dissected down to the joint. A hole, nine millimeters in diameter and three and one-half centimeters in depth, was bored into the joint about one inch above the posterior superior spine, the auger entering between sacrum and ilium and pointing in an outward and downward direction as shown in Figure 1. The auger removed bone from sacrum and ilium.

A hole of similar dimensions was bored about one inch below the posterior superior spine, in same plane but not quite parallel to the first hole, the auger pointing in an upward and outward direction.

Dowel grafts, eleven millimeters in diameter, from the tibia were driven into the holes. These grafts, being slightly larger than the holes, fit snugly; they are not tight enough to spread the joint surfaces (Fig. 1), but by causing tension on the posterior sacro-iliac ligament, they increase the stability of the joint. The wound was closed without drainage and a cast was applied (Fig. 2).

The reason for not having the holes parallel is, that no matter what the tendency to a gliding motion in the joint may be, it is absolutely prevented, the transplants acting as the key which holds the wheel to the axle. This is mechanically efficient, and further, when union takes place between transplant and ilium we have a condition similar to that presented when the key becomes rusted into the wheel and axle. Any degree of mobility is impossible.

In the above case the cast was removed two months after operation; a belt was applied, and the patient was allowed on crutches. These were discarded three months after the operation, at which time he was back to his optimum weight and had no distressing symptoms. In December 1919, about four years later, he came to the office, reporting that he had been in military service and had had no untoward symptoms whatsoever. He was seen again in the summer of 1924, about eight years after operation, when an x-ray examination was made (Fig. 3). In this radiograph the transplants are no longer visible but there is a fusion of a greater portion of the joint.

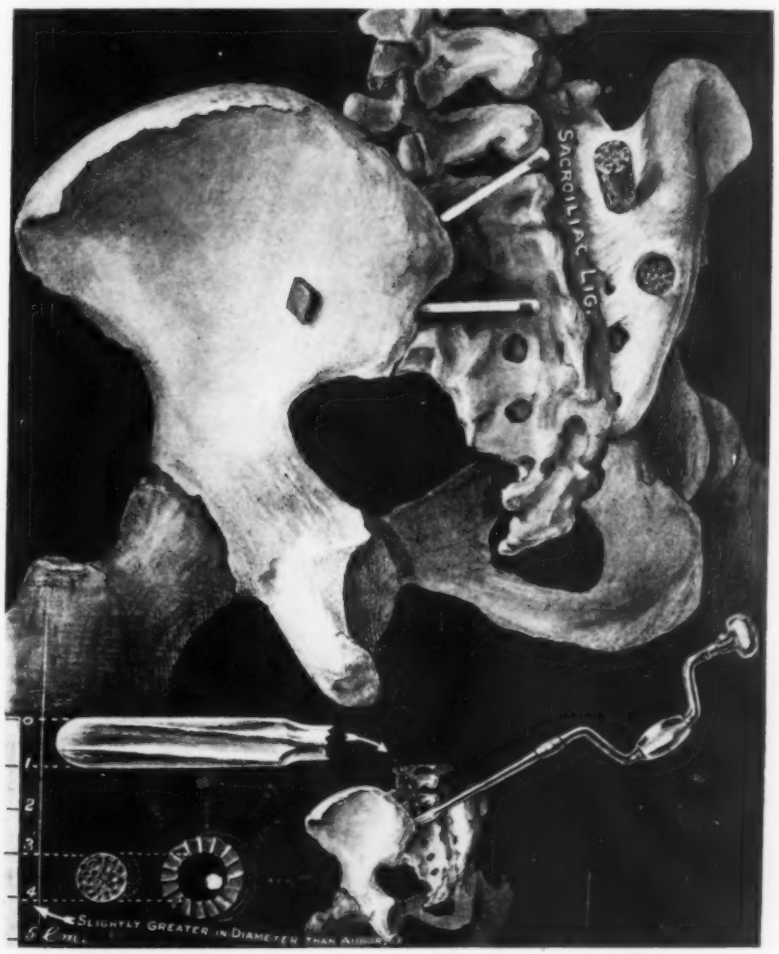


FIG. 1

Drawing of sacro-iliac joint showing one bone key in position, the other about to be driven home. Matches indicate angulation between bone keys. Diagram in lower left indicates relative size of auger and bone key.

FIG. 2

X-ray taken two months after operation, showing bone keys in position.

FIG. 3

X-ray taken eight years after bone-key operation. Bone keys have been absorbed, but greater portion of joint is fused.

Since performing this operation, several similar operations have been done with equally good results. In conclusion, the writer wishes to state that he does not advise this operation where there is extensive destruction of bone, but only in those cases where the transplants can get a firm hold without encroaching too much upon soft infected bone tissue. In the case mentioned, at the operation about one-half dram of pus oozed from each hole bored. This caused apprehension for a time, but the subsequent course, including primary healing, demonstrated that there was little cause for fear of failure.

This operation would be especially indicated in intractable cases of relaxation of the sacro-iliac joint where external supports had failed of their purpose, in cases of arthritis, and in cases of tuberculosis where massive bone destruction is not present.

THE BACTERICIDAL ACTION OF VARIOUS METALS UPON CERTAIN ORGANISMS IN RELATION TO METALLIC INTERNAL FIXATION OF TISSUES*

BY J. TORRANCE RUGH, M.D., PHILADELPHIA, PA.

Many years ago, the writer saw a laboratory demonstration of the effects of several metals upon colonies of staphylococcus albus and the change produced by certain of these metals was so marked as compared with others, that it suggested the thought that this reaction might prove sufficiently interesting and valuable to warrant the determination of the behavior of certain more virulent organisms in the presence of those metals which might be used for internal fixation purposes.

The burial of various metals for suture or internal fixation of bony parts has been followed for many years and the degree of intolerance for certain ones as compared with the tolerance for others has long been recognized. To what this intolerance was due has been variously conjectured, but is generally recognized as an extremely complex subject by reason of the ever changing biochemical problems in the tissues and the variation in atomic weights, solubility, basic combinations with various chemicals, electrical reactions, oxygen-combining properties, and other such factors on the part of the metals. We know that in the use of plates for fractures, or nails and screws for plastic work in the bones, the tissues of some patients tolerate the steel well and bone callus will surround and completely enshrine the plate, while in others the metal must be removed in a few weeks because of its destructive action. The explanation of these facts doubtless lies in the biochemical reaction of the tissue fluids upon the metals, which is constantly varying with the state of the body health. The solution of the problem of tissue tolerance for metals, however, rests upon more factors than those mentioned. In 1910, Professor Lange presented a paper before this Association (*American Journal of Orthopaedic Surgery*, VIII, 344, November 1910) on "Support for the Spondylitic Spine by Means of Buried Steel Bars Attached to the Vertebrae", and in it he reported the results of experiments to ascertain the tolerance of different metals by the tissues. These experiments revealed several very interesting factors. First, it was found that the chemical character or composition of the substance was of great importance. Those readily oxidized by the body fluids (such as iron, steel, copper, zinc, nickel, *etc.*,) are apt to cause an aseptic suppuration in the tissues, which renders healing more difficult and which is likely to result in their elimination from the body. Tin was found to be the best tolerated of all metals tried, but to be of any value it must be used as a

*Read at Meeting of American Orthopaedic Association held at Washington, D. C., May 1–3, 1928.

heavy coating on steel, and Lange reported one case in which steel bars thus treated had remained in the spine for over two years with complete relief to the spinal condition.

In our experiments, several series of tests were made with sixteen metals including platinum, gold, copper, sheet aluminum, galvanized iron (Zn on iron), Monell metal, brass, aluminum casting (twenty per cent. zinc), bronze, annealed steel, carbon steel, nickel, brass wire, silver, lead, and tin. Two types of pyogenic organisms were used,—namely, staphylococcus aureus and bacillus pyocyaneus. Two kinds of culture medium were used, blood agar and plain agar. Colonies of each organism were planted on each medium and incubated for twenty-four hours to secure a generous growth. A small piece of each metal was then placed on a colony in the two media and the results of incubation at the end of twenty-four and forty-eight hours were carefully noted. Streptococci and the more malignant organisms were not investigated as it was not felt that any implanted or applied agent of low solvency would likely exert any inhibitive influence upon these virulent and rapidly multiplying germs. The results of these observations have been tabulated in detail but as there were no strikingly demonstrative inhibitory effects shown by any of the sixteen metals upon the colonies of the two organisms in either medium, it was deemed not worth while to utilize the time in demonstrating these. The only outstanding facts observed were that annealed steel, carbon steel, aluminum casting, and lead all showed the effect of oxidation at the end of twenty-four hours, and the steel and aluminum after forty-eight hours were covered with heavy crystals from the action of the organisms upon them or the chemical result of bacterial growth upon the media. There was no destruction of the colonies in contact with the metals but it was noted that platinum, silver, gold, and tin remained absolutely untarnished and unchanged. It is realized that criticism may be made as to the conclusiveness of such tests in the laboratory, but the report is offered in the effort to elucidate one of the factors in our problem of internal fixation by metals.

CONCLUSIONS

1. Certain metals by reason of their chemistry, electric reactions, solubility and other physical properties are less tolerated by human tissues than are others.

2. No demonstrable inhibitive effect was shown upon the colonies of staphylococcus aureus and bacillus pyocyaneus on blood agar and plain agar media.

3. It has been demonstrated that certain metals such as tin, gold, platinum, and silver cause less reaction in the body tissues than others and therefore, under such circumstances, organisms carried by the blood stream would be less prone to infect adjacent areas than where metals causing irritation were used.

VITAL CAPACITY AND MUSCLE STUDY IN ONE HUNDRED CASES OF SCOLIOSIS

BY A. E. FLAGSTAD, M.D. AND SARA KOLLMAN, R.N., ST. PAUL, MINN.

Scoliosis has long been discussed and studied, especially as to etiology, types of curves, and treatment. Comparatively little has been written concerning the important changes that accompany lateral curvature, especially relative to the chest and abdominal viscera. However, while this is true, some very important and extensive studies have been done; perhaps most noteworthy is the work of Schulthess, Bachmann, Lorenz and Saxl, and Bauner. All seem to agree that, when lateral distortion of the spine occurs, there is a definite functional impairment of the heart and lungs. A great deal, however, is still left to be explained. Further study is necessary to clarify several important questions that immediately arise when one analyzes the statements relative to chest changes.

How much distortion is necessary before impairment of function occurs; that is, how much will nature accommodate itself to the deformity without injury? What criterion have we to go by in examining a chest distorted secondary to lateral curvature? It is true that we can, in a measure, determine the changes of the heart, but how about the lungs?

As we recall our student days, we were taught a definite technique for examining a fairly definite type, or variation of this type, of resonant chamber, the thorax. We were taught that certain fairly definite types of vibration and sounds were present in the normal chest. Variations from the normal occurred in diseases of the heart or lungs, due to changes in or about these organs. But given a resonant chamber and two vital organs distorted by deformity,—where is our standard for comparison? When are we dealing with true pathology and when is the deviation from the normal due to external distortion and secondary accommodations of the thoracic organs?

Most authors feel that a great many curvatures, especially with distortion of thorax, subsequently develop tuberculosis. A great number have cardiac impairment secondary to chest distortion. Bachmann in one hundred and ninety-seven autopsies of scoliotic patients of moderate and severe types, found tuberculous disease of the lungs in twenty-eight and three-tenths per cent., while in the milder degrees of scoliosis there were sixty per cent. so affected. Moss found apex infiltration in sixty and two-tenths per cent. of one hundred scoliotic children between five and sixteen years. Kaminer and Zade report that seventy-three per cent. of scoliotic women have lung involvement, predominately of the lung on the side of convexity. The explanation for this high percentage of tuberculosis in scoliosis was thought to be due to the immobility and stasis of the apices, especially on the side of convexity.

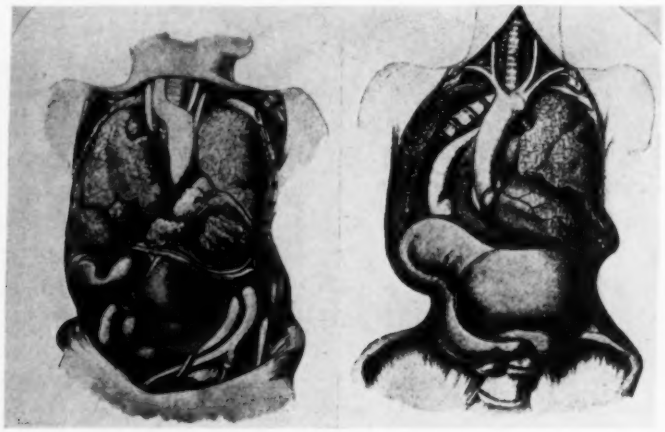
While one cannot ignore autopsy findings, yet the explanation for the high incidence based upon restricted excursion is somewhat contrary to our present-day treatment of pulmonary tuberculosis by means of pneumothorax and thoracoplasty. In bone and joint tuberculosis it is the joints most active and subject to stress and strain that are more frequently affected. Rest of the diseased part is the cardinal principle of treatment.

At the Gillette State Hospital we can recall very few lateral curvature cases that have subsequently developed a pulmonary or joint lesion. Lorenz and Saxl and Bauner warn against drawing conclusions as to apical affection in the deformed thorax, due to the fact that percussion and auscultation are frequently altered secondary to chest distortion.

In September 1926, we began a study of vital capacity in relation to lateral curvatures, feeling that this, in a way, would give us an index as to the respiratory damage in the deformed thorax. During the year we made repeated readings on one hundred and thirteen cases. At least four hundred different readings were recorded in this group. Some patients had as many as ten readings, others several, and a very few only one. At each reading three trials were allowed and the highest reading recorded. In conjunction with this, we twice made readings of every patient in the hospital, excepting the children under five years of age. We also made readings on a group of nurses and found our figures corresponded with those reported by Dr. Myers. We checked the von Pirquet, Manteau, blood Wassermann, urine, and blood picture. Weight, standing and lying height, and chest circumference were taken. Our normal standards were taken from the tables according to Myers and Stewart[2]. Chest expansion was taken on repeated occasions. In a great many cases three chest readings were made: an upper, middle, and lower thoracic reading. Vital capacity was also checked according to chest circumference from Dr. Myers' table. An examination of the musculature was made by Miss Kollman. In every case the muscles of the thoracic cavity, back, shoulder girdle, and abdomen were studied. The muscles were recorded as poor, fair, and good, according to the strength of their response. The idea we had in mind was to determine, if possible, the relationship between the degree of curvature, muscles, and vital capacity. Lorenz and Saxl refer to the fact that as the chest becomes deformed, especially with rotation, expansion is limited, and most of the work falls on the diaphragm. The question which arises here is: does the diaphragm hypertrophy when more work is thrown upon it? In extensive infantile paralysis, particularly in the acute and early convalescent phases, where we are dealing with extensive involvement of the chest, shoulder, back, and abdominal muscles, most of the work falls upon the diaphragm, and yet the patient suffers little or no respiratory discomfort; unless the diaphragm is directly involved. Do the thoracic muscles in the presence or absence of chest distortion have much influence upon vital capacity? See Chart III (top), muscles poor, vital capacity ninety-six per cent.; also Chart IV, poor muscles, mild and moderate curves, vital capacity normal.

CHART I

Photographs of dissections, showing distortion of chest and abdominal viscera, secondary to lateral curvature.



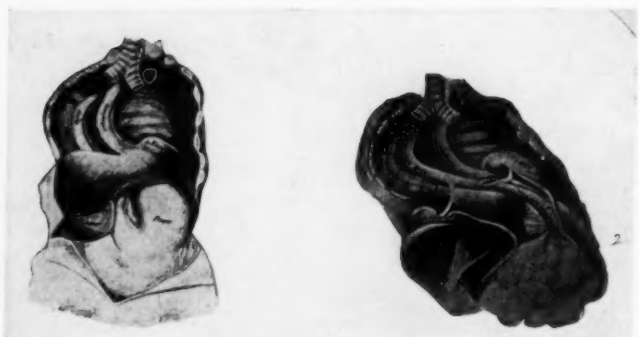
a *b*

FIG. 1

Fig. 1-*a*. Severe left lumbodorsal curve. Note distortion of abdominal vessels and viscera, but very little chest distortion.

Fig. 1-*b*. Severe dorsal curve. Compression of lung on side of convexity; heart displaced to left.

(Drawings from Bouvier, after Bachmann)



a *b*

FIG. 2

Fig. 2-*a*. Severe dorsal curve. Note deviation of aorta and aesophagus.

Fig. 2-*b*. Severe dorsal lumbar curve. Note distortion of abdominal viscera.

(Drawings from Lorenz and Saxl)

CHART II

Roentgen-ray classification of all cases; films carefully studied and grouped into mild, moderate and severe curves according to the amount of involvement of dorsal spine and chest change; then this information added to Chart III.

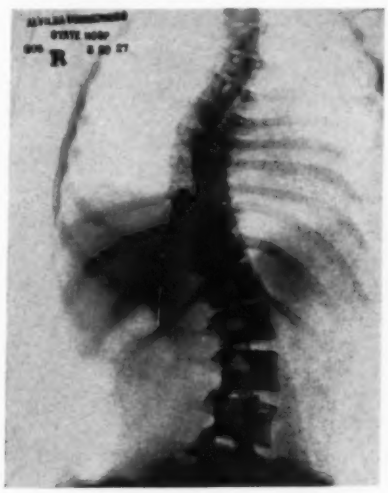


FIG. 3

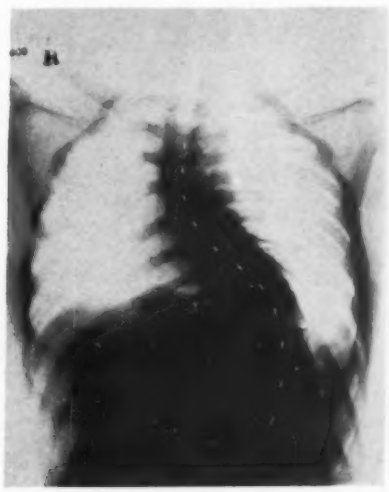


FIG. 4

FIG. 5

FIG. 6

Fig. 3. Illustrates mild right dorsal curve; no chest change; slight rotation. Vital capacity 85 per cent.

Fig. 4. Illustrates moderate curve, severe left dorsolumbar; very slight chest change. Vital capacity 80 per cent.

Fig. 5. Broad *C* right dorsal severe curve. Note compression of lung on side of convexity; compensation left lung; chest change severe. Vital capacity 52 per cent.

Fig. 6. Severe right dorsal lumbar. Note compression of right lung, accommodation of left. Note course of trachea and bronchi. Vital capacity 45 per cent.

CHART III

Manner in which all cases were studied and recorded. Roentgen-ray diagnosis of type of curve and chest changes recorded last (after studied according to Chart II). These cases were then classified as mild, moderate and severe, depending upon amount of chest change. Charts II and III were worked out independently of each other.

LAUDNA CHAPELAIN
Age 6 years

DATE	WEIGHT	HEIGHT		VITAL CAPACITY		CHEST EXPANSION		
		With Jacket	Without Jacket	With Jacket	Without Jacket	Expiration	Inspiration	Number of inches
Dec. 13 1926	43½ lbs. With Brace	St. Lying 46"			1200	21½"	23"	1½"
Jan. 11 1927					1350	21½"	23½"	2"
March 5 1927					1300			
June 28 1927	41½ lbs With brace							
Aug. 27 1927				800				
Sept. 7 1927	43½ lbs.			1000	1250	21½"	24"	2½"
May 1 1928	43½ lbs. With Brace	St. Lying 48½"	St. Lying 46"	1100	1400	21½"	24"	2½"

Diagnosis: Left upper dorsal, right lower dorso lumbar scoliosis due to Anterior Poliomyelitis.

Roentgen Reading: Mild left upper dorsal and right lower dorso lumbar lateral curve. There is very little rotation and very little chest change.

Classified as mild curve according to chest change.

Muscle Test

Left		Right
Fair	Anterior Neck	Fair
Good	Posterior Neck	Good
Fair	Lateral Neck	Fair
Good	Back:	Good
Poor	Anterior Abdominals	Poor
Poor	Lateral Abdominals	Poor
Upper Poor		Upper Poor
Middle Poor	Trapezius	Middle Poor
Lower Poor		Lower Trace
Good	Rhomboids	Poor
Poor	Serratus Magnus	Good
Fair	Intercostals	Fair
Poor	Latissimus Dorsi	Poor
Trace	Clavicular Pectoralis Major	Good
Trace	Sternal Pectoralis Major	Trace
Poor	Deltoid	Fair

S.A.R.

Wassermann is negative
Von Pirquet is negative
Mantoux is negative

NOTE: Normal Vital Capacity in relation to standing Height is 1355
Patient's vital capacity is 96% of Normal.

Mild left dorsal curve; no chest change; muscles very poor. Vital capacity 96 per cent. Etiology: poliomyelitis.

ADELINE BOCK
Age 14 years

DATE	WEIGHT	HEIGHT		VITAL CAPACITY		CHEST EXPANSION		
		With Plaster Cast	Without cast	With Plaster cast	Without Cast	Expiration	Inspiration	Number of inches
Nov. 5, 1926					2100			
Nov. 27, 1926					1900			
Dec. 1, 1926	105½ lbs. with cast							
Dec. 13, 1926			St. 58½" Lying 58½"		2200	28½"	31½"	3"
Jan. 11 1927				2000				
Feb. 4, 1927		St. 58½" Lying 58½"		1800				
March 4 1927					2200	28"	31"	3"
March10 1927		OPERATION	Fusion of Spine					
July 27 1927	89 lbs.				2250	27"	31½"	4½"
Aug. 26 1927	87 lbs.			2000	2300	27"	31½"	4½"

Diagnosis: Adolescent scoliosis.

Roentgen Reading: Right lower dorso lumbar lateral curve with fairly marked rotation. Curve extends from 7th dorsal to 4th lumbar vertebrae. Height of curve is opposite 11th, 12th dorsal and 1st lumbar. Rotation is present. Mild upper dorsal compensatory curve to left. Chest cavity has very little change. Very little distortion of ribs. Lungs are very slightly distorted and heart is slightly enlarged. Classified as mild curve according to chest change.

Muscle Test

Left		Right
Normal	Anterior Neck	Normal
Normal	Posterior Neck	Normal
Normal	Lateral Neck	Normal
Good	Back:	Good
Poor	Anterior Abdominals	Poor
Good	Lateral Abdominals	Poor
Upper Good		Upper Good
Middle Good	Trapezius	Middle Good
Lower Good		Lower Good
Good	Rhomboids	Good
Good	Serratus Magnus	Normal
Good	Intercostals	Good
Good	Latissimus Dorsi	Good
Normal	Clavicular Pectoralis Major	Normal
Normal	Sternal Pectoralis Major	Normal
Normal	Deltoid	Normal

S.A.R.

Wassermann is Negative
Von Pirquet is Negative
Mantoux is Negative

NOTE: Normal Vital Capacity in relation to standing Height is 2327.
Patient's Vital Capacity is 94% of normal.

Mild moderate right dorsal, left lumbar severe curve. Very slight chest change; muscles good. Vital capacity 94 per cent.; same after fusion. Etiology: idiopathic.

CHART III (continued)

PELVIS DEFORMITY

Age 17 years

DATE	WEIGHT	HEIGHT		VITAL CAPACITY		CHEST EXPANSION		
		WITH JACKET	WITHOUT JACKET	WITH JACKET	WITHOUT JACKET	EXPIRATION	INSPIRATION	DIFFERENCE
Nov. 11, 1926	81 lb.		St. 5'8 Ins. ---	800	900	24½"	25½"	1"
Nov. 30, 1926				800	900	23½"	25"	1½"
Jan. 27, 1927				900	1050	23½"	23½"	1"
March 24 1927				800	900			

Note: Normal Vital Capacity in relation to standing height is 2125
Patient's Vital Capacity is 42% of normal.

Diagnosis: Old empyema, left chest, with secondary right cervical dorsal scoliosis.

Roentgen Reading: Marked rt. cer. dorsal scoliosis from 3rd cervical to 11th dorsal vertebrae. Height of curve opposite 8th dorsal. Severe rotation. Left dorso lumber curve from 12th dorsal to 3rd lumber.

Thoracic cavity markedly distorted. Entire lower half of left lung collapsed. Left apex apparently functioning. Normal shadow present. The right lung is moderately compressed throughout as result of convexity. Heart appears slightly enlarged.

Classified as severe curve according to chest change.

Muscle Test

Left		Right
Good	Anterior Neck	Good
Normal	Posterior Neck	Fair
Good	Lateral Neck	Good
	Back: Good	
Fair+	Anterior Abdominals	Good
Poor	Lateral	Good
Upper Normal		Normal Lower
Middle Good	Trapezius	Fair+ Middle
Lower Good		Fair+ Lower
Poor	Rhomboids	Good
Good	Serratus Magnus	Normal
Good	Intercostals	Good
Good	Latissimus Dorsi	Good
Good	Clavicular Pectoralis Major	Good
Good	Sternal Pectoralis Major	Good

Normal-Driscid — Normal

Wassermann Negative
Von Pirquet Negative
Mantoux Negative

Severe right cervical dorsal curvature; marked rotation and severe chest change; muscles good. Vital capacity 42 per cent. Etiology: empyema.

Examination of the chest was made in a number of cases, both in this group and in private practice. In conjunction with this examination a tracing was made of the thorax in a number of cases by taking a lead strip and moulding it to the chest at the height of deformity. Roentgen pictures of the spine were taken of all cases. Stereoscopic pictures of the chest were taken in sixty cases. The pictures were carefully studied and the cases grouped in fair, moderate, and severe groups, according to the amount of deformity of the thorax and distortion of the heart and lungs. A mild case refers to a mild lateral distortion of the dorsal vertebra with little or no rotation and very little chest change; a moderate case, a moderate chest change with definite rotation; a severe case, severe chest changes with marked rotation. We may, therefore, have a mild dorsal curve with a very severe lumbar curve and yet in this study the case is listed as mild. All cases were grouped according to chest distortion without knowledge of chest expansion, muscle power, or vital capacity. These were grouped as illustrated by Chart II. Vital capacity readings were taken in seventy-three cases (with and without jacket) to determine, if possible, the influence of a rigid support upon respiratory function.

In all, we had one hundred cases included in the final study. Four cases were excluded because of positive tuberculin tests. In several cases the stereoscopic plates suggested lung pathology and in seven cases the data was insufficient.

SUMMARY

In this study of one hundred cases the average age of the patient was thirteen years, the youngest five years, and the oldest forty-one years. Cooperation was very good; almost without exception the patients were most interested. Twelve hundred vital capacity trials were given and the four hundred highest readings recorded, giving an average of three readings per individual made at different intervals. Muscles were checked in all cases by Miss Kollman. Readings were done in the main by one person. Calculated normal vital capacity, according to standing height from Dr. Stewart's table, was used and percentage of normal vital capacity figured from this. In addition percentage of normal vital capacity, according to Dr. Myers' tables of chest circumference and surface areas, was used.

Our conclusions follow, after observation over a period of one and a half years in which physical examination, roentgen examination, laboratory, muscle check, and repeated vital capacity readings were done.

CONCLUSIONS

1. Physical examination of the deformed chest must be carefully interpreted, because changes in palpation, auscultation, and percussion do occur secondary to chest distortion. These vary according to the amount of deformity present. In suspicious cases stereoscopic plates, fluoroscopic study, and tuberculin tests should be done, especially with reference to a diagnosis of tuberculosis. A careful check of all curvature cases, we believe, will demonstrate that tuberculosis is not nearly so frequent as heretofore reported. Cardiac complication and respiratory embarrassment are a sequela in the severe cases and dyspnea, cardiac hypertrophy, and irregularity, as a rule, are present. These patients, as a general rule, suffer impaired general health due to their chest and abdominal distortion. Yates, in Archives of Surgery (XII, 257, January 1926) says: "The resistance, defense, growth, and repair of the interthoracic structures, as well as the entire organism, are commensurate to and with vital capacity".

2. Stereoscopic examination is important, especially in the severe cases. The lung on the side of convexity is compressed and distorted; the lung on the concave side follows the curvature, is the larger and more active, except in empyema curves. The trachea takes a fairly straight course. The heart, as a rule, in severe curvatures is enlarged and displaced to the side opposite the convexity. Stereoscopic and fluoroscopic study of a large number of curvature cases, especially the severe type, will do much to clarify the changes of the heart and lungs in the deformed thorax.

3. Vital capacity bears a definite relationship to the location, degree of curvature, and rotation. When the height of the curve is in the lower dorsal and lumbar region, vital capacity is not especially affected, even in the most severe types of curvature. Chart I shows how little chest distortion is present in severe lumbar curves. In mild and moderate cases, regardless of the muscle power, vital capacity is within normal limits. In

Comparison of Vital Capacity in Relation to Poor and Good Abdominal Muscles

GROUPS: MILD, MODERATE, SEVERE — ACCORDING TO STEREO CHEST CHANGES

Poor Muscles

Type of Curve			*V.C.*	*Chest Exp.*	*Abdom. Convex*	*Muscles Concave*	*Diagnosis*
1. Mild Curve	—	Low Dorsal	79%	1½ inches	Poor	Poor	Poliomyelitis
2. "	"	(S) L.D.R.L.	71%	1¾ "	"	"	"
3. "	"	(C) L.D.L.	90%	2 "	"	"	"
4. "	"	(C) R.D.L.	100%	1½ "	"	"	"
5. "	"	(C) R.D.L.	76%	2¼ "	Trace	Trace	"
6. "	"	(C) L.D.L.	96%	2 "	Poor	"	"
7. "	"	(C) R.D.	93%	3 "	"	Poor	"
8. "	"	(C) R.D.	112%	1¾ "	"	"	"
9. "	"	(C) R.D.	68%	2 "	"	Trace	"
10. "	"	(S) L.C.D.	113%	2 "	"	"	"

Average Vital Capacity 90%
Average Chest Expansion 1.9 inches

1. Moderate		(C) R.D.L.	110%	3	inches	Poor	Poor	Poliomyelitis
2. "		(S) R.D.L.D.L.	75%	3½	"	"	"	"
3. "		(C) R.D.L.	110%	4	"	"	"	"
4. "		(C) R.D.	72%	3¼	"	"	"	"
5. "		(S) R.L.D.	84%	1¾	"	"	"	"
6. "		(S) R.D.L.	70%	2	"	"	"	"
7. "		(C) R.D.	90%	2½	"	"	"	"
8. "		(C) R.D.	82%	2½	"	"	Fair	"

Average Vital Capacity 86%
Average Chest Expansion 2.3 inches

1. Severe		(C) R.D.	52%	1½	inches	Poor	Poor	Poliomyelitis
2. "		(S) R.D.L.D.L.	62%	3	"	"	"	"
3. "		(C) R.C.D.	45%	2	"	"	"	"
4. "		(S) R.D.L.L.	90%	2½	"	"	"	"
5. "		(S) R.D.L.L.	76%	1½	"	"	"	"
6. "		(S) L.C.D.R.D.L.	51%	1	"	"	"	Empyema
7. "		(S) L.C.D.	35%	1	"	"	"	Poliomyelitis
8. "		(C) R.C.D.	70%	1½	"	"	"	"
9. "		(C) R.D.	46%	2	"	"	"	"
10. "		(S) R.C.D.	31%	2	"	"	"	"
11. "		(S) R.C.D.	25%	1½	"	"	"	"

Average Vital Capacity 53%
Average Chest Expansion 1.7 inches

Good Muscles

Type of Curve			*V.C.*	*Chest Exp.*	*Abdom. Convex*	*Muscles Concave*	*Diagnosis*
1. Mild Curve	(S)	R.D.L.L.	146%	2½ inches	Good	Normal	Cong. Anomaly
2. " "	(C)	L.D.	91%	3 "	"	Good	Idiopathic
3. " "	(C)	R.D.	96%	1½ "	"	"	"
4. " "	(C)	R.D.	99%	1½ "	"	"	"
5. " "	(C)	R.D.L.	100%	2½ "	Fair	Fair	"
6. " "	(C)	R.L.D.L.	97%	3 "	"	"	Poliomyelitis
7. " "	(S)	R.D.	87%	2½ "	Good	Good	"
8. " "	(C)	R.D.L.	97%	2 "	"	"	"

Average Vital Capacity 100%
Average Chest Expansion 2.2 inches

1. Moderate	(S)	L.D.L.R.L.	99%	3	inches	Good	Good	Idiopathic
2. "	(S)	R.D.L.L.	90%	2	"	Fair	"	Cong. Anomaly
3. "	(S)	R.D.L.L.	106%	1¾	"	Good	"	Idiopathic
4. "	(S)	R.D.L.	120%	2½	"	"	"	"
5. "	(S)	R.D.L.	95%	2	"	Fair	"	Arthritis
6. "	(C)	R.D.	73%	1½	"	Good	"	Idiopathic
7. "	(C)	R.D.	89%	2½	"	"	"	"
8. "	(S)	R.D.L.L.	99%	2	"	"	"	"
9 "	(S)	R.D.L.	89%	3	"	Fair	"	Spina Bifida
10. "	(C)	R.D.L.	95%	2½	"	Good	"	Cong. Anomaly
11. "	(C)	R.D.L.	82%	1½	"	"	"	Spina Bifida

Average Vital Capacity 94.3%
Average Chest Expansion 2.3 inches

1. Severe	(C)	R.D.L.	50%	2	inches	Good	Good	Idiopathic
2. "	(C)	R.D.L.	77%	2½	"	Fair	"	"
3. "	(S)	R.D.L.L.	89%	2½	"	"	"	Poliomyelitis
4. "	(C)	R.D.L.	74%	3½	"	Good	"	"
5. "	(S)	R.D.L.L.	50%	2½	"	Fair	"	Cong. Anomaly
6. "	(C)	R.D.	55%	1¾	"	"	"	Idiopathic
7. "	(S)	L.D.L.	86%	2	"	Good	Normal	"
8. "	(S)	L.C.D.R.D.L.	46%	1½	"	Fair	Good	"
9. "	(S)	R.D.	60%	2½	"	"	Fair	Poliomyelitis
10 "	(C)	R.D.	35%	2	"	Good	Good	"

Average Vital Capacity 62.2%
Average Chest Expansion 2.3 inches

Comparison of vital capacity in poor and good abdominal muscle groups: fair group not included. Influence of abdominal muscles:

1. Mild curves; vital capacity, poor abdominal muscle 90 per cent., good abdominal muscle group 100 per cent.—difference 10 per cent.
2. Moderate curves; vital capacity, poor group 86 per cent., good group 94.3 per cent.—difference 8.3 per cent.
3. Severe curves; vital capacity, poor group 53 per cent., good group 62.3 per cent.—difference 9.3 per cent.

Average difference all groups between poor and good abdominal muscles, 9.2 per cent.

Influence curves: Poor abdominal muscle group, mild curves, vital capacity 90 per cent.; severe curves, vital capacity 53 per cent.,—difference vital capacity is 37 per cent.

Good abdominal muscles, mild curve, vital capacity 100 per cent.; severe curves vital capacity 62.2 per cent.— difference vital capacity is 37.7 per cent.

Influence of severe mid-dorsal curves on vital capacity is four times greater than influence of muscle power on vital capacity.

Key to Chart. (S) and (C) refer to type of curve; R.D. Right dorsal; L.C.D. Left cervical dorsal; R.D.L. Right dorsal lumbar.

CHART V

Analysis of One Hundred Cases

Types of Curves in Relation to Muscle Groups

		Poor Muscles	*Fair Muscles*	*Good Muscles*	*Total*
	Mild Curves	19	9	7	35
1.	Moderate Curves	6	10	13	29
	Severe Curves	11	17	8	36
	Total	36	36	28	100

Average Chest Expansion in Relation to Curves and Muscle Groups

		Poor Muscles	*Fair Muscles*	*Good Muscles*
	Mild Curves	2.1 inches	2.2 inches	2.2 inches
2.	Moderate Curves	3.1 "	2.1 "	2.1 "
	Severe Curves	1.8 "	1.7 "	2.2 "

Average Vital Capacity in Relation to Curves and Muscle Groups

		Poor Muscles	*Fair Muscles*	*Good Muscles*
	Mild Curves	V.C. 84%	V.C. 99%	98%
3.	Moderate Curves	V.C. 86%	V.C. 83%	%
	Severe Curves	V.C. 53%	V.C. 53%	%

Analysis of Curves in Relation to Diagnosis

	Poliomyelitis	64
	Idiopathic	23
	Congenital Anomaly	13
4.	Empyema	4
	Fr'edreich's Ataxia	1
	Arthritis	1
	Undiagnosed	7
		113

Analysis of one hundred cases: thirty-five mild curves; twenty-nine moderate curves, and thirty-six severe curves.

1. Analysis of neck, chest, and abdominal muscles in relation to curves. Thirty-six cases poor muscles, thirty-six fair muscles, and twenty-eight cases good muscles.

2. Analysis of chest expansion relative to curves and muscle groups. No significant change in mild and moderate curves regardless of muscle group. Severe curves in poor and fair muscle group, mild reduction.

3. Analysis vital capacity in relation to curves and muscle groups.

Muscle influence:

a. Mild curves—vital capacity varies 84 per cent. in poor muscle to 98 per cent. in good muscle group; difference 14 per cent.

b. Moderate curves—vital capacity varies 86 per cent. poor muscle to 92 per cent. in good muscle group; difference 6 per cent.

c. Severe curves—vital capacity varies 53 per cent. poor muscles to 65 per cent. good muscles; difference 12 per cent.

Average influence muscles 10.5 per cent.

Analysis influence of curves on vital capacity in various muscle groups:

a. Poor muscle group—difference vital capacity between mild and severe curves 31 per cent.

b. Fair muscle group—difference vital capacity between mild and severe curves 46 per cent.

c. Good muscles—difference vital capacity between mild and severe curves 33 per cent.

Average difference all groups is 35 per cent. Influence of severe thoracic deformity on vital capacity is three times as important as muscle power.

4. Analysis of cases relative to etiology.

(Note the high percentage of poliomyelitis)

severe cases the vital capacity varies from fifty-three to sixty-five per cent. of normal vital capacity, according to standing height. In a dozen cases a comparison was made of the percentage of normal vital capacity, according to standing height, chest circumference and surface area. The averages in these cases follow: standing height sixty-two and eight-tenths per cent., chest circumference sixty and six-tenths per cent., surface area forty-eight and eight-tenths per cent. Without exception, in these and a great many other cases, the vital capacity, according to surface area, was found to be lower than a standing height.

4. In severe curves there is a difference of thirteen per cent. in vital capacity between the poor muscle and good muscle groups. This suggests that the muscles of the neck, thorax, and abdomen have slight influence on vital capacity. A plaster or leather support reduces, on an average, the vital capacity fourteen per cent. This is probably due to the decreased limitation of excursion of the thorax and diaphragm.

5. Chest expansion in severe cases is slightly reduced. Expansion is affected more by the severity of the curve than by muscle power.

6. Reduction of the vital capacity in severe curves is probably due to several factors:

a. Embarrassment of the heart and lungs secondary to chest deformity.

b. Reduced mobility of the thorax and diaphragm due to lateral curvature and rotation.

c. In a few cases probably partial paralysis of the diaphragm is present[4]. Unfortunately we had no facilities to check this by fluoroscopic examination.

7. Treatment must be based upon a careful analysis of all cases. Vital capacity, we believe, will in a measure give an index as to the damage done and the operative risk, especially in thoracic, spinal, and abdominal surgery[10]. Where the vital capacity approaches fifty or sixty per cent. of normal, operation should not be considered lightly. In severe cases this is probably an explanation for the shock that frequently follows operative procedure and every precaution should be taken to properly prepare the patient. No treatment today at our command can do much to alter the cardiac and respiratory damage already done.

Every mild curve must be considered a potential severe curve, in which irreparable damage will be done. Prevention, in a great many cases, is possible and will follow in the path of cooperation between all medical groups. For after all the cure *par excellence* is the curvature that would have developed had it not been prevented.

We wish to acknowledge our appreciation to the members of the Gillette State Hospital for their help and cooperation; also to Dr. J. A. Myers for his helpful suggestions.

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A CONSERVATIVE OPERATION FOR BUNIONS

BY EARL D. MCBRIDE, M.D., OKLAHOMA CITY, OKLA.

The operation here described is the result of an effort to overcome some of the difficulties which result from the more destructive operations for the relief of hallux valgus. It is especially applicable to younger individuals, since reconstruction of anatomical alignment may be accomplished without joint destruction.

ADVANTAGES

The advantages are as follows:

(1) Deformity is corrected without resection of the joint, or fracture of the metatarsal.
(2) Normal architecture of the toes is approached.
(3) Mechanical force which causes the deformity is corrected.
(4) The scar is located safely from irritation.
(5) The period of disability is greatly lessened.

FIG. 1

The internal sesamoid is displaced outward and contributes to the increase of deformity.

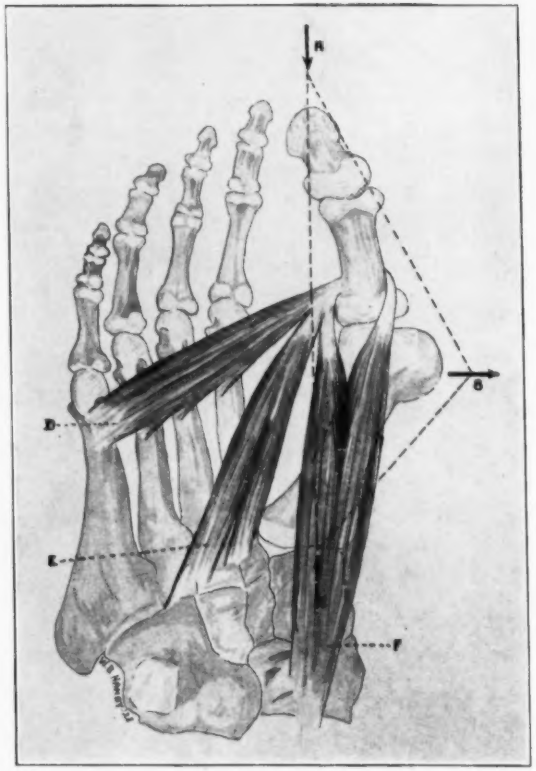

FIG. 2

The mechanical force which causes hallux valgus is the shortening of the line *A-C*. The pull of the adductor muscles plus the pressure of a short shoe at *A* increases the acuteness of the angle *B*. *D*. Adductor hallucis; transverse head. *E*. Adductor hallucis; oblique head. *F*. Flexor hallucis brevis.

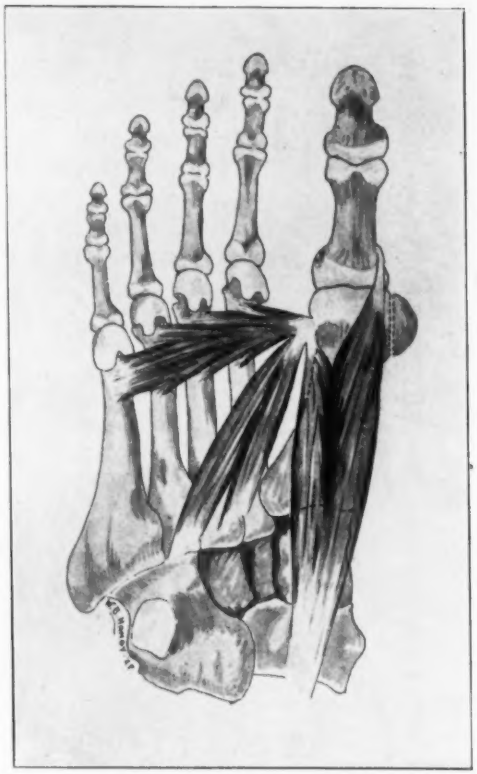

FIG. 3

Transplanting of the conjoined tendon of the adductors from the first phalanx to the head of the metatarsal bone creates a mechanical stress favorable to correction of the deformity.

INDICATIONS

This operation is suitable for any case except where there are marked changes in the articular surface, or extreme deformity, or in that of hallux rigidus.

THEORY OF DEFORMITY

One of the greatest mechanical factors in causing deformity is contraction of the muscles whose conjoined tendons insert into the base of the external aspect of the first phalanx of the big toe. These muscles, composed of the transverse and oblique heads of the adductor hallucis and the flexor hallucis brevis, have considerable power.

When the toe is everted slightly, as would naturally happen in a short shoe, these muscles have a great advantage mechanically over the abductors of the toe.

When radiographs of feet with hallux valgus deformity are reviewed, it is found that in a majority of the cases the shadow of the internal sesamoid bone appears between the heads of the first and second metatarsals. This bone is attached to the conjoined adductor tendon as well as to the

FIG. 4

Incision slightly curved laterally to tendon of the extensor hallucis longus.

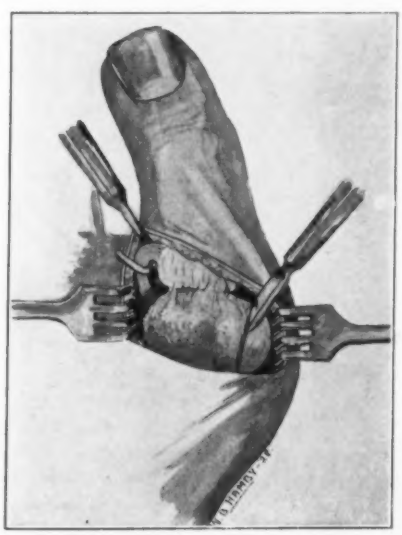

FIG. 5

The conjoined tendon of the transverse and oblique heads of the adductor hallucis and the flexor hallucis brevis, are exposed and severed from their attachments. The exostosis is exposed through the same incision.

FIG. 6

Transplanting the conjoined tendon into the head of the metatarsal. The prominence of the metatarsal head has been removed.

favorable to correction of the deformity.

hallucis; oblique head. *F*. Flexor hallucis brevis.

flexor hallucis brevis. It, therefore, is gradually pulled outward as deformity increases. The sesamoid often becomes fixed in this position because of inflammatory changes, and it creates a force which tends to push the head of the first metatarsal inward at each step.

We have then a line of force which shortens one side of a triangle, and lessens the angle formed by the two other sides (See Fig. 2). The side which becomes shorter is represented by a line from the tip of the first toe to the base of the first metatarsal. The phalanges represent one of the other sides and the first metatarsal bone the other.

OBJECT OF OPERATION

The object of the operation, then, is to release this abnormal mechanical force and restore the alignment of the metatarsal bone and phalanges. To accomplish this, the conjoined tendon of the base of the outer aspect of the first phalanx is released from its attachment and transplanted into the head of the first metatarsal. The external sesamoid is removed if it is eroded, abnormal in shape, or displaced. The bursa and prominence on the medial aspect of the head of the metatarsal are then removed and an ideal yet conservative correction is obtained.

FIG. 7
Case shown in Figure 1 after operation.

TECHNIQUE OF OPERATION

(1) Usual preparation.

(2) Incision, two inches in length, along external border of extensor hallucis longus with its center over the joint.

(3) Keep close to metatarsal head and dissect downward. No important structures are severed and the small vessels just external to the extensor hallucis may be avoided. As dissection is made, the conjoined tendon of the adductor hallucis group is observed at its point of insertion into the external side of the base of the first phalanx. It should be carefully exposed and severed from its insertion. Just beneath and between this tendon and the metatarsal head is the internal sesamoid, which is imbedded in the outer head of the flexor hallucis brevis. The sesamoid is dissected out, if such procedure is indicated. The dissection should be done without any more trauma than is absolutely necessary. Small bone-holding forceps are of great aid, as the sesamoid is very difficult to hold while dissecting, because it is so deep down in the small incision. A heavy tonsil tenaculum is quite useful for this purpose. The conjoined tendon of the adductor muscles and external head of the flexor hallucis brevis are transplanted into the dorsum of the head of the first metatarsal bone.

The incision is now retracted medially and subcutaneous dissection made to expose the bursa and bone prominence on the inner side of the metatarsal head. The veins can usually be avoided. The bursa is dissected out; the bone prominence is chiseled away; the toe is corrected, and the capsule repaired.

When the wound is closed, the first and the second metatarsals close tightly together. The toe is manipulated into a little overcorrection and a very light plaster slipper is applied to maintain this correction. The cast and stitches are removed in from one week to ten days, and the toe is held in correction by adhesive plaster. Weight-bearing is allowed at the end of two weeks. The toe should be held in correction by adhesive plaster for from four to six weeks.

OPERATIVE CORRECTION OF OLD STERNOCLAVICULAR DISLOCATION

BY CHARLES LEROY LOWMAN, M.D., F.A.C.S., LOS ANGELES, CALIF.

The success of an operation for the correction of a clavicle wrenched from its attachment to the sternum, leads us to report the method as an addition to the plastic surgery of bones and joints accomplished by the use of fascia.

CASE REPORT

The patient, a vigorous man of twenty-seven years, presented himself because of weakness in the shoulder and inability to use his arm without pain and weakness. He was unable to play tennis, as his right arm was involved. Examination revealed a dislocation of the sternal end of the right clavicle. The ligaments were completely ruptured and the head of the clavicle was riding upward and forward a distance of an inch, making an unsightly lump. This area was slightly sensitive to pressure, and pressure on the head succeeded in only partially reducing the displacement. All movements of the arm redisplaced the bone, and months of treatment by pressure and other conservative means had utterly failed.

Operation: Skin incision parallel and just below the clavicle about four inches long. Skin retracted. An *H*-shaped incision through the deep fascia and periosteum made, with the bar of the *H* vertical over the joint. These two flaps dissected inwardly and outwardly, exposing the head of the bone at the joint. Lifted from the socket, the head was found to have thickened, prong-like extensions on its deep aspect, probably due to extensive callus formation where the posterior ligament and periosteum were torn from the head and adjacent shaft. This made such an increase in the size of the head that it partially explained the failure of pressure to sink the head into the socket. This thickened area was dressed off and a good replacement made possible. Next, a strip of fascia lata was taken from the thigh, one and one-half inches wide and almost five inches long, rolled up tightly with the edge stitched about two-thirds of its length. This was passed through the holes drilled obliquely through the sternum to the center of the socket and similarly through the end of the clavicle, emerging at about the center of the articulating surface. These holes were made with a quarter-inch burr drill. The fascial tether, where it passed across the joint, not only acted like the teres ligament in the hip joint, but a small amount of fullness was allowed to occur in the joint space forming an interarticular pad to act like a film cartilage and prevent arthrodesis. The excess on the other end was carried completely around the neck of the bone, fastened to itself, and stitched to the heavy tissue as far below and behind as possible. The redundant inner end of this strip was unrolled, spread out, and carried outward across the anterior aspect of the joint as an anterior ligament. The tongue-like flaps of the fibroperiosteal material made by the *H*-incision were then brought together. Due to the stretching and irritation produced in these tissues, it was found that there was sufficient excess to allow their ends to be lapped and imbricated, further fortifying the joint. The arm and shoulder were encased in a spica cast, and after an uneventful recovery, the patient was allowed up in about a week.

At the end of three weeks a top section of the cast was removed and the stitches taken out. The cast was worn for two or three weeks more, practically as an aeroplane splint. It was then removed and physiotherapy treatments begun. The result was

wholly satisfactory. Swelling over operated area disappeared rapidly under treatment and patient returned to Arizona nine weeks after operation.

He was allowed cautious use of the arm for a few months. The function of arm and shoulder were restored to normal and the patient then returned to regular activity as a contractor and builder. His tennis-playing was resumed. The result was one hundred per cent. satisfactory both as to form and function.

As a matter of interest we found that a flat-bladed subperiosteal elevator, followed by the use of a similarly curved retractor passed around and behind the head and neck, safeguarded the important vessels lying behind the area.

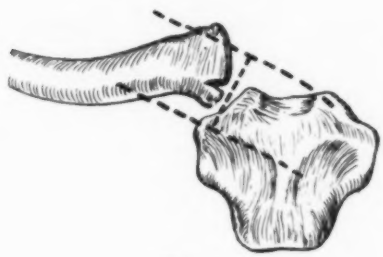

FIG. 1

Incision and projecting spicule.

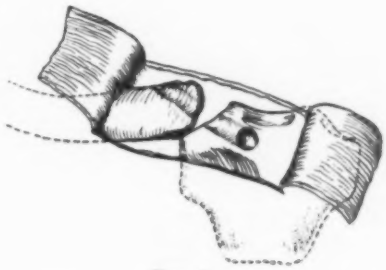

FIG. 2

Joint exposure, showing spicule trimmed off and holes drilled.

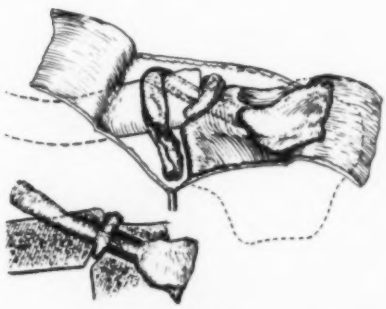

FIG. 3

Inserted fascia. The redundant bulge in joint forms new fibrocartilage, preventing ankylosis. Free distal end is wrapped round neck and sutured below.

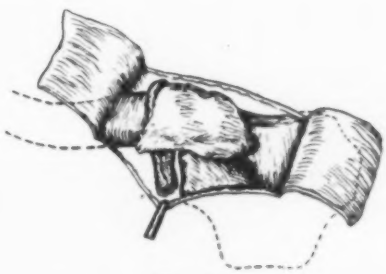

FIG. 4

Free proximal flap reflected outward, making new anterior ligament.

PREVENTION OF DEFORMITIES OF THE KNEE IN ARTHRITIS

BY LORING T. SWAIM, M.D., BOSTON

Robert Brigham Hospital

The commonest deformity of the knee in arthritis is flexion and subluxation with outward rotation. Varying degrees of permanent flexion are very crippling, because walking is painful and awkward, and injures the knee through trauma. This aggravates the disease, causing further changes in the joint even after the active arthritis has ceased. This deformity presents a grave problem in the plan of reconstruction of the chronic arthritic patient, as, no matter what procedures one may use,—conservative stretching, manipulation or surgery,—rarely is the knee a complete functional success thereafter.

Flexion deformities can be prevented early in the disease, and so simply that it can be done by anyone. During the last few years the procedure described in this paper has been used successfully in early cases, and has been a tremendous help with cases but slightly flexed.

The cause for flexion of the knee is the desire of the patient to relieve pain during the acute, painful stage in the disease. Slight flexion is more comfortable when a knee is swollen, because it loosens the hamstring pull on the posterior capsule; it allows more room for the swollen tissues in the joint by relaxing the posterior capsule itself; and the feeling of fulness and pain is therefore diminished. To accomplish this flexion, a supporting

FIG. 1

Flexion weight on heels and hips. Note subluxation of right knee and slight outward rotation.

pillow is usually placed directly under the knee, or the knees are bent when lying on the side. Comfort is the prime desire, and flexion gives this by relaxation and protection from slight jars. In a short time, more flexion is necessary for relief, and the supporting pillow becomes a permanent necessity.

FIG. 2

Anteroposterior view. Flexion, subluxation and outward rotation.

After the flexion takes place and complete extension has become impossible, through shortening of the hamstrings and capsule, the second deformity begins. This is subluxation (Fig. 1). The entire weight of the leg resting on the heel and hip, the capsule and ligaments of the knee having been relaxed by flexion, there is no support for the tibia. Even the support from the quadriceps is lost, as this is relaxed and no longer used, because it hurts to contract it, and because it is forgotten. Furthermore, the hamstrings are used to steady the knee, and their pull increases the natural tendency of the tibia to drop down on the femoral condyles in flexion. Subluxation is inevitable, and will be complete if the crucial ligaments are diseased.

With subluxation, comes outward rotation of the tibia on the femur (Fig. 2), due largely, I believe, to the outward turn of the foot, aided materially by the weight of the bed clothes. The outer hamstrings aid rotation in flexion by their stronger leverage. The shape of the condyles may also be a factor when the knee is flexed.

The degree of subluxation and outward rotation depends on the degree of flexion and the amount of support for the tibia from the pillow. The more the flexion, cartilage destruction, and relaxation of the joint structures, the greater the subluxation. Once present it cannot be overcome by the patient unaided, and it is one of the most difficult problems for the ortho-

FIG. 3

Lateral view, subluxated outwardly rotated knee, even with only slight permanent flexion.

FIG. 4
Split cast. Note subluxation right knee.

paedic surgeon. Permanent flexion should not be allowed to occur. Every arthritic runs the risk of flexion if the knees are involved, and it should always be borne in mind, and relief given before flexion occurs.

Recognizing the causes which force the patient to put a pillow under his knee and flex it,—namely, pain and tension,—if we put the knee at rest, we will accomplish his object for him, giving comfort and protection before flexion occurs. This can be accomplished with a light plaster-of-Paris cast, applied from the hip to the toes with the leg extended, but not hyperextended, as this is painful. A cast, so applied, gives rest and comfort from slight trauma of motion. The swelling is not as great where there is no tension of the muscles for support, and irritation subsides. The cast must be bivalved within three days, as the dangers of fixation are real, and cannot be overlooked. Stiffness will always result as the inflammation in the joint subsides, if the cast is left on too long. A few days of complete rest is sufficient in most cases.

FIG. 5
Correct pillow position to prevent and overcome subluxation of knees.

It has been our custom to remove the shell daily for short periods of voluntary motion at first, while hot fomentations are applied. The length of the periods of exercise is dependent on the condition of the joint and the painful reactions produced in the knee. The dangers from flexion during the day are not great after the acute stage is passed, but at night, during sleep, the legs are almost always flexed a little in all of us, and especially so in the arthritic. It is during these ten hours of possible flexion that the shells are used. Of course, motion in the morning may be a little difficult, but it is never as difficult to flex a knee as to extend it. The shell is removed for longer and longer intervals during the day, as indicated by the reactions from exercise. The night protection is continued, however, until the active disease is controlled. Sleeping is invariably better, and rest is more complete, when the knee is protected in its removable shell. If flexion deformity can be prevented, subluxation will not occur and rotation is unlikely.

The inflammation subsides more quickly and there is less thickening with this protective treatment than ordinarily takes place without it, so that active exercise and use can be instituted much earlier and more effectively to prevent stiffness than in the unprotected knee. The relief of pain and inflammation tends to result in a better functioning knee and shortens inactivity.

To go a step further, we have found that even after a knee has become flexed, a night shell, applied at the extreme angle of extension, will often so relax the muscles and ligaments that more extension without trauma can be obtained gradually by frequent renewal of a straighter shell, until a Thomas caliper splint can be used in the day. In slightly flexed knees, another method of helping prevent subluxation during the day is to support the tibial head in a cuff of webbing covered with felt, and attached to a Balkan frame by heavy elastic cord. It is an excellent exerciser during the day. The cuff and elastic placed at the upper end of the tibia prevent subluxation in flexion, and lighten the work of flexion, and by increased pressure when straightening the knee, keep the tibia well up in place.

The dangers of the flexed, subluxated knee cannot be overemphasized. One is forced to take notice, when one sees the frequency with which the

FIG. 6

Elastic cuff exercises to overcome subluxation flexion and to strengthen the quadriceps.

hip and ankle become involved after flexion has occurred. This is undoubtedly due to additional strain on these joints from bad positions and knee deformity. Hip flexion contractures are frequent, and the arthritic changes take place in these joints more often when the knee is permanently flexed, due to trauma to the hip and ankle.

The ankle suffers for two reasons,—undue pressure on the os calcis and strain of the tibio-astragaloid joint, and circulatory congestion in the ankle, which invariably follows flexion deformities of the knee. It has been usual, after straightening a knee, to see the oedema, congestion and active arthritis in the ankle, as well as the pain in the hip and low back, subside. The unnatural position of the knee affects the hip and ankle deleteriously. If flexion of the knee can be prevented, the hip and ankle stand a far better chance of avoiding danger from arthritis.

With these methods of support, both at rest and during exercise periods, flexion, subluxation and outward rotation of the arthritic knee can be prevented, and in some cases where the deformity has occurred, it can be reasonably corrected. If more care were exercised in the beginning of the active arthritis to foresee and prevent this one deformity, most patients with chronic arthritis would be on their feet walking much earlier than at present is possible. After the deformity is well established, the only means of correction is by painful use of splints, with fair results; ether manipulation, many times not entirely satisfactory; and operations, which give only a degree of normal function. Flexion deformities can be prevented if taken early and the knee carefully protected and exercised as has been described.

THE ETIOLOGY OF RHEUMATOID ARTHRITIS*

BY ALEXANDER GIBSON, F.R.C.S., (ENG.), WINNIPEG, CANADA

Gallons of ink and reams of paper have been used up in an attempt to answer the question, "What is the cause of Rheumatoid Arthritis?". It is well to understand what we mean by the word "cause" and that is a subject on which philosophers have argued from the days of Aristotle onward.

According to Mill, "Scientifically the cause of anything is the total assemblage of the conditions that precede its appearance, and we have no right to give the name of cause to one of them exclusive of the others". But "among the conditions of an event there are always one or two that stand in specially close relation to it from our point of view . . . such closely related conditions we find it convenient to single out by a term which expresses their analogy to . . . human volition".

The flower in the garden is the resultant of two main factors, the seed and the soil. There are many other factors,—temperature, moisture, sunlight, etc. Sometimes there is a *tertium quid* which stands in special relation to the result, as in the case of the nitrifying bacteria and the leguminosae, but always the prime consideration is two-fold, the seed and the soil. It is from that point of view that I propose to discuss the cause of rheumatoid arthritis.

There are two main groups of theories at present regarding this disease:

1. That it is non-infective in character.
2. That it is infective.

The former postulates that the disease can manifest itself in the absence of organisms, that it is essentially due to disordered body chemistry.

The latter holds that whether tissue changes resulting from non-bacterial causes be present or not, it is essential that organisms be present locally.

Let us consider first the non-infective factors. The name of Pemberton is specially associated with these. He has observed delayed glucose removal from the blood, lowered basal metabolic rate in twenty per cent. of cases, and finds that the capillaries contain a smaller number of red blood cells than do the ordinary blood vessels. Goldthwait has emphasized the importance of faulty posture, leading to visceroptosis. Briefly the non-infective factors fall into three groups.

1. Congenital predisposition. This has been insisted upon by Crookshank. It is at least a possibility. Differences in detailed structure of parts of the body are at least as great as differences in form and feature.

*Read at the meeting of the American Orthopaedic Association, Washington, May 2, 1928.

This is true for the gross anatomy of the dissecting-room and is in all probability equally true for cellular structure. Hence it is reasonable to assume that the blood supply of joints, and the nervous control of that blood supply vary indefinitely, so that irritants,—chemical, thermal, or bacterial,—may readily find certain individuals resistant while others succumb. The prominence given in recent years to the reticulo-endothelial system in medical literature suggests that variations in the efficiency of this mechanism may predispose to rheumatoid arthritis. There is an aroma of predestination about this "congenital" view of the matter which tends to repel further research.

2. Endocrine disturbances. The proponents of this idea do not back their statements with much tangible evidence. The following quotation is typical:

"Llewellyn has pointed out that, like acute rheumatism, rheumatoid arthritis is linked with states of hypo- and hyper- thyroidism and with deficiency of ovarian and pancreatic secretion. It is becoming appreciated that administration of various hormones, especially of small doses of thyroid and parathyroid gland, produces definite benefit whilst withdrawal is followed by recession (?) of the disease."

"A considerable mass of evidence has now accumulated which goes to show that the underlying element for a large group of rheumatic disorders which manifest a failure of adaptation to environment, climatic and general, as a result of lowered metabolism, is to be found in a condition of subthyroidism with suboxidation."

Reduction of the blood calcium has been observed and, in obese women of forty-five or fifty, joint changes are recorded to which has been applied the term "climacteric arthritis". But even if it be granted that the endocrine balance is upset, is it not more probable that abnormalities of ductless glands and changes in the articular mechanism are the evidence, in their respective anatomical situations, of a common disturbing factor?

3. "Faulty alimentation" (Osgood).

Cawadias has emphasized recently the importance of sulphur metabolism. He finds in arthritic patients a slight excess in excretion of ethereal sulphates in the urine. This he interprets as meaning either "a certain loss in chondroitin — sulphuric acid which is an important constitutent of cartilage—or an abnormal protein metabolism". Another observer has found diminished free hydrochloric acid in the gastric juice.

Ellis regards phosphorus as the key of the position. He looks on rheumatoid arthritis as "a trophic and autonomic nervous paralysis, showing itself in wasting and loss of tone of the muscles before any joint injury supervenes. The muscles are under constant tonic irritation and degeneration." "This is associated with deficiency in assimilation or utilization of phosphoric acid and other phosphates."

Sometimes the alimentary lesions are frankly surgical in character. They are situated mainly in the right iliac fossa, and most of them suggest reasons for delayed peristalsis. This delay leads to the elaboration and

absorption of toxins, which then find their way to the joint, or of actual organisms which reach a similar destination.

It is interesting to note that Pemberton found that "glucose ingested by the mouth reaches the synovial fluid with such rapidity as sometimes to exceed in concentration the glucose in the blood". If glucose, why not toxins from the alimentary canal? But is there any evidence to show that rheumatoid arthritis is the result of an irritant absorbed from the joint cavity?

Rowlands regards rheumatoid arthritis as being a "deficiency disease" comparable with rickets, scurvy, or beri-beri.

Experimenting with rats, he found that "a vitamin-B deficiency in the diet of animals leads to a lowered vitality as shown by the subnormal temperature; secondly a deficiency animal is prone to infection". The animals showed marked intestinal stasis and this was associated with pronounced atrophy of the caecum and intestine generally. Plummer in discussion, stated that "the ordinary every-day diet only supplied approximately two-thirds of our full requirement of vitamin-B".

The theory of infection is widely held, and there is much to be said in its favor. In the simplest form, it assumes that organisms reach a joint and there initiate the series of changes resulting in the production of the disease. In another form it states that for some reason "the joint has become hypersensitive, and in the event of any toxin reaching it from an infective focus, such as a single tooth with apical infection, reacts in an anaphylactic manner".

Intermittent hydrarthrosis is cited as a probable example of this sequence.

Swift and Boots were unable to sensitize the joints with killed non-hemolytic streptococci. On the other hand McMeans states, "Herry and later Faber used the toxins of the streptococcus to sensitize the joints". Upon the injection of the streptococcus intravenously at a subsequent period, a definite arthritis was produced. In several animals that had recovered spontaneously from arthritis, Cole was able to provoke a relapse by another intravenous injection of the same streptococcus. In some interesting experiments on chronic cholecystitis just published, Wilkie has the statement, "Strangely enough the first (intravenous) injection produced no pathological changes but served merely as a sensitizer". If for the gall-bladder, why not for the joints?

The next question is, assuming a sensitized joint, is there any evidence that toxin from a distance can produce an arthritis? I know of no evidence to show that toxin, as distinct from organisms, can produce the typical histological picture of inflammation with plentiful small round-celled infiltration and proliferation and multiplication of the villi.

Further, the clinical course of the disease,—first one joint, then another becoming hot, swollen, inflamed, painful, then settling down,—is much more characteristic of actual infection than of a toxin.

In this respect, rheumatoid arthritis has a distinct resemblance to

acute rheumatic fever, a disease which is now generally regarded as organismal in character, the local changes being associated with the presence of organisms locally. The presence of the organisms has not been demonstrated in the Aschoff bodies, but the analogy between these and the miliary tubercle or the miliary gumma is too striking for us to reject the conclusion that they are there.

Is there any evidence that organisms are present in or around a joint, the subject of rheumatoid arthritis? It is generally stated as an objection to the infective theory that the joint fluid almost constantly shows no growth on culture.

This is hardly a valid objection. In the first place, it is possible for all the joint changes associated with rheumatoid arthritis to be present without organisms being in the joint cavity. That is admitted. In the second place, it is possible that the joint fluid contains a substance inhibiting the growth of organisms, hence rendering the joint cavity sterile at an early date, just as bile adhering to the mucosa of the gall-bladder will interfere with the culture of organisms situated in the wall of that organ. We know also that a joint which is closed can readily overcome a fair measure of gross infection.

On many occasions, organisms have been cultured from the synovial membrane, and it may be that culture of the subsynovial tissue obtained without entering the joint cavity may give more frequent positive results.

The question of focal infection in the production of rheumatoid arthritis has been written about *ad nauseam*. We have all seen cases that underwent dramatic improvement after the removal of an infected tooth or a septic tonsil. We have also seen cases where the extraction of numerous infected teeth and other culpable foci was followed by no improvement at all. We have concluded that the organisms were in some secondary or metastatic focus or foci either about the joints themselves or elsewhere. The difficulty is to know where.

It is rather surprising that in view of the work of Rosenow published in 1914, so little has been done to follow up the lead he gave that the lymphatic glands might be worth study. We have seen Still's disease in children, with joints painful and swollen, and with lymphoid tissue involved, yet as far as I know the glands in this condition have not been studied bacteriologically. In Rowlands' experiments when deficiency animals were fed micro-organisms with the food, the lymphoid tissue of the intestine was "full of micro-organisms", streptococci being the easiest to demonstrate. In Wilkie's work streptococci were demonstrated in the cystic lymph gland in eighty-six per cent. of cases. Yet so recently as August 1926, Hirsch described a case under the title "Chronic Arthritis with Involvement of the Lymphatic Glands". There was a typical polyarthritis with swelling of epitrochlear, axillary, and inguinal glands, and of the spleen. A lymphatic gland was removed from the axilla, and submitted to histological examination, but there is no record of a culture being made.

I have been unable to obtain information regarding the exact distribution of lymphoid tissue in animals in relation to their diet and environment. Looked at as a whole, however, it is evident that lymphoid tissue is most plentifully supplied in the regions where organismal invasion is most probable. Thus we have it in abundant association with the alimentary tract and the respiratory tract. So far as I know it is absent from the kidneys, ureter, and bladder.

At the root of each of the limbs there is a lymph node station comparatively small in amount. That is a reasonable arrangement when one considers the protective action of the skin covering the limbs. There are some difficulties in the way of investigating the lymph glands. Patients do not readily submit to operation unless there is a fair prospect of improvement held out to them, and removal of the lymph gland is a definite operation requiring the strictest technique. The glands are frequently very small, even when heavily infected. There are no glands draining the joints and the joints alone, as the cystic lymph gland drains the gall-bladder. The lymph nodes obtainable are therefore capable of being infected from other sources than the joint.

Removal of the deep inguinal glands in a number of cases of rheumatoid arthritis has furnished abundant evidence that these glands contain active organisms capable of growth. It is seldom that only one organism has been found in the glands. The commonest organism found by Cadham is thus described (Unpublished).

"This is a small pleomorphic organism about five-tenths by one micron, with a tendency to occur in pairs, and at times resembles a diplococcus, non-motile, and in older cultures gram-positive but in younger cultures the gram stain is indefinite. Growth of the original culture is slow. On whole blood agar it appears on the sixth to the ninth day. Colonies are discrete, originally translucent, later becoming a cloudy white. It is aerobic and facultatively anaerobic."

The sceptics will regard this as just another of the long list of bacterial "also-rans" in the chronic arthritis handicap.

The specificity of the organism involved is a large and difficult question. The most recent experiments I have noted are those of Parish and Okell. They conclude that "all hemolytic streptococci make the same toxin and that there is only one identifiable antibody,—namely what is generally known as scarlet fever antitoxin".

This is an extreme statement, at variance with the work of other observers, particularly Rosenow. Without further evidence we cannot accept it.

The importance of the matter lies in the relation of the work to serum preparations. On the whole the use of vaccines has been disappointing, not only in this, but in many other disease conditions. The striking successes such as have been scored in diphtheria, in tetanus, and recently in scarlet fever are to be credited to serums.

As far as I am aware, no work on the use of serums in rheumatoid

arthritis is published. The arresting publication of Small regarding the use of an anti-rheumatic serum awaits confirmation and general acceptance. Some of the results obtained by Cadham, who has kindly associated himself with me in the study of this condition, from the use of a specific serum in septicaemia have been very striking, sufficiently so to encourage prosecution of this investigation along the same lines.

We excised deep inguinal glands and prepared a vaccine from the organisms obtained. This was given subcutaneously in graduated doses of 100,000,000 to 500,000,000 weekly. In no case was there a violent reaction. In every case some benefit appeared to be derived. The chief improvement noted was that acute exacerbations of the disease were stopped. One very bad case has been under treatment for over a year with definite though not dramatic improvement.

We also prepared a serum by injecting rabbits, and have tried it in one or two cases. It is hoped to have more full details at a later date but the collection of evidence is very slow.

The literature of this subject is vast. After an extensive and painstaking survey of it, one feels much as did Omar some eight hundred years ago, looking back upon the time of his youth when he

"did eagerly frequent
Doctor and Sage and heard great argument
About it and about; but evermore
Came out by the same door as in I went".

The problem is an insistent one, and the onus of solving it lies heavily on the shoulders of our specialty. I believe that concerted effort on the part of our members and their associates can solve it, and that the key to the solution rests in the bacteriology of the lymphatic glands.

DISCUSSION

Dr. M. S. Henderson, Rochester, Minn.: The subject of polyarthritis is a vast one. There is not very much that I can add.

Dr. Gibson mentioned infection. From a clinical viewpoint there is no doubt there are factors besides infection in polyarthritis. Heredity is one; we see it in families. There will be four or five members of one family who will develop polyarthritis. In our work in the Mayo Clinic, we have made many investigative studies, but there is nothing which, taken by itself, seems to explain these cases of arthritis. It is more than probable that the symptoms are due to more than one factor, and that both infection and toxins emanating from the alimentary canal may be factors. Dr. Rea Smith of Los Angeles has been recircuiting and resecting the large bowel and has secured some promising results. I do believe that infection is the prominent factor in the majority of cases. I have had an opportunity of observing Dr. Rosenow's work for many years; I have seen him take material from the tonsils and teeth, inject it into animals, and later show us the lesions in the joints. This has been done in so many cases that there is no doubt in my mind that infection is the primary cause.

Dr. Gibson mentioned the necessity of a concerted effort on the part of orthopaedists, surgeons, and internists. Only too often the orthopaedist is appealed to at the last, when the deformities are multiple and disabling. If the disease is studied by a group in the early stages, no doubt many cases can be brought under control that otherwise could not.

This disease is of tremendous economic importance, and I feel sure that Dr. Osgood will mention something of this in his discussion.

Dr. Robert B. Osgood, Boston, Mass.: As Dr. Henderson has said, there are two main theories as to the cause of rheumatoid arthritis,—infectious and non-infectious. To my mind that is just the trouble. We seem to take one or the other. Dr. Gibson so wisely in his most thoughtful paper has said there is the seed and the soil. We must be sure to remember that there are at least these two factors, the seed and the soil. We are dealing in arthritis with probably more than one cause, and probably more than two. He asks the question, whether there is any evidence to show that rheumatoid arthritis is the result of a toxin localizing in the joint cavity. We have been waiting for this evidence and I think we have it. Dr. Joseph Freiberg has carried out some experiments at the Children's Hospital to our satisfaction. He was able to produce with bacteria-free toxins injected into the joint itself the definite and characteristic changes of atrophic or proliferative arthritis. His results were satisfactory not only to us but to Prof. Zinsser and Prof. Morse. I think his work will stand.

Dr. Gibson speaks of these reactions as a species of anaphylaxis. I am not wise about the distinction of the terms. I know people like Prof. Zinsser like to speak of these cases as a species of allergy rather than anaphylaxis. One cannot have an allergic result without there being some focus somewhere in the body. We should consider probably that many of these joint phenomena are allergic phenomena.

The study of the lymphatic glands is interesting. I hope Dr. Baer will speak of that. Some work has been going on at the Children's Hospital under the direction of Dr. John Kuhns. He has shown unquestionably that the inguinal glands do not seem to drain the knee joint at all; it is the deep femoral glands. The work needs confirmation.

I wish to call your attention to the fact that in Rowland's work, he notes that when deficiency animals are fed with bacteria the lymphoid tissues of the intestine are full of micro-organisms, even though there have been no bacteria or germs found in the joints themselves or the joint fluids; and that perhaps the streptococci in some form have been more commonly found than others. That leads me to suggest that this problem is not, as has been stated, a problem of a single focus or a single germ but is a problem of the resistance of the body to many germs and that the contributing and predisposing causes are perhaps the important ones. Overcoming the exciting causes may often suffice to break through the vicious circle and heal the patient. It is very common, however, to have the patient recover without removal of the foci. As the body resistance rises, the patient is able to take care of the foci himself. No more striking example can be found than that of forty children who were sent to an outdoor hospital preparatory to removal of tonsils. The children were given heliotherapy and outdoor life and at the end of six months it was found that only four out of the forty needed the tonsils removed. We must not forget the resistance of the body to foci as well as other conditions. Do not understand me as advocating that we should not remove the foci, but do understand me to believe that you should do something else besides removing the foci. Pemberton's series showed forty per cent. recovered with the foci still in the body, while seventeen per cent. only recovered with the foci removed, which means we must do something else besides remove the foci.

The economic situation is most important in this disease, probably the most important of any disease we have, because these patients do not die; they live and are dependent on their fellowmen. We know, as Dr. Gibson said, that under appropriate treatment in the early cases we can arrest the disease. There is now an International Committee for the study of rheumatic diseases, on the American committee of which are three members of this Association. I feel this Committee may help propagate this disease and popularize rational methods of treatment, so that the attention which the importance of this problem seems to demand will be focused more generally upon it.

Dr. W. S. Baer, Baltimore, Md.: We are very much indebted to Dr. Gibson for presenting this paper in the analytical way he has done. I have been interested in the

subject for a great many years and, after studying each phase of the situation, the bacteriologic point of view has appealed to me more than any other.

My first real consideration of the subject came about 1919, just after the War, when I was called in to see a very dear friend who had a marked type of what we termed chronic infectious arthritis. It involved all of his joints as well as the heart. All medication apparently seemed to be of no avail. Remembering Dr. Rosenow's work at that time, we decided to remove the lymphatic glands to see if by any possible means we could get organisms from the glands at that time. We found the streptococcus hemolyticus. A vaccine was made from that streptococcus hemolyticus which was given to the patient. Almost immediately, I might say, his acute symptoms subsided. He is now well, at least all the activity of the disease has subsided, though the deformity which usually goes with that disease is present, to a certain extent. To all intents and purposes, that stopped the trouble. So, from that time, I have been very much interested in the study of the glands in relation to arthritis deformans.

Arthritis deformans to my mind would represent an equation thus: infection $+ x =$ arthritis deformans. What x means we do not know. You may call it allergy if you wish. Perhaps it is associated with internal glandular secretion. There may be many factors. I think we are pretty nearly at the place where, if we limit the infection, we stop the arthritis deformans, whatever the other term of the equation may be. Taking for granted, therefore, that there are specific organisms which may be found in the glands, we went to work to find out in how many glands in cases of arthritis deformans we could obtain the organisms. That search was very interesting. At first we found very few. In Johns Hopkins Hospital we found none whatsoever. In another laboratory under a very able pathologist we used to get, at first, about two in ten. In well equipped laboratories now we get about seven or eight positive cultures out of ten. Why that discrepancy? The discrepancy depends entirely on the bacteriology. These organisms are not very common. They are so attenuated that they do not grow immediately. In some cases it is six weeks before we can identify the organisms or get sufficient growth to identify them. It depends on the way the culture is grown. We practically never obtain organisms in four or five days and it is generally two or three weeks. As I have said before, it may be as long as six weeks before we obtain organisms. What does the ordinary bacteriologist do in our large hospital and college laboratories? If at the end of forty-eight hours he sees no growth, the majority of the cultures go into the sink. If at the end of seventy-two hours he sees nothing, ninety per cent. of bacteriologists in our schools will throw them away. You cannot get it that way. It must be grown on proper media, starting exactly with the proper maceration of the tissues and then transferring from one media to another until the growth has been sufficient to bring them back. I should say in arthritis deformans we are now obtaining organisms in selected cases, not in cases that have been going on for fifteen years, but in the more recent cases. I think I can safely say that in seventy-five per cent. of the cases we are now obtaining organisms. The organism obtained is generally the viridans, the nonhemolytic streptococcus, and to a lesser extent the hemolytic streptococcus. In one or two cases we have obtained the staphylococcus, and in one case both from the knee and from the glands the gonococcus. It does not make much difference what gland you take it from. We generally try to take it from the gland which drains the joint; but arthritis deformans is not a local disease, it is a constitutional disease. It not only takes in the joint surface, but it takes in the other tissues of the body. It takes in, for instance, the parietal layer of the pleura. We must treat these cases from the point of view of a constitutional disease and not from the point of view of a local disease, just as we would treat tuberculosis. Light and those things which raise the resistance of the body aid greatly in eliminating the infection. The bacteria are killed off by raising the body resistance.

I should not go into the question of treatment. I simply want to make the statement that we have no specific organisms. It is invariably a streptococcus, either nonhemolytic or hemolytic. We have found that we could make an autogenous vaccine

from the organism which we have grown, and in order to prove that we have the proper organism, we see whether that patient reacts to that organism by sensitization, before beginning treatment. Our doses are very low at first and then carried very high, according to the reaction. We are gratified at the present time with the results obtained with the use of a vaccine made from the autogenous organisms.

With regard to the production of bacteria in joints and in glands at the same time, I should like to ask Dr. Shands in a few moments to give you some figures on the organisms from glands and the same organisms from joints in a large series taken from children in the hospital at large, not especially arthritis deformans cases except in one case of arthritis deformans with Still's disease. This showed organisms in the glands and also in the joints as well. Taking cases that were not considered arthritis deformans, as a rule, we did not get organisms in the glands. If we took cultures, we did not get any organisms. There were no organisms in those glands, unless it was a very acute stage of tonsillitis or some infection, but in the ordinary run of children on whom the experiment was made the organisms were practically negative in the normal individual.

Dr. A. R. Shands, Jr., Washington, D. C.: We have a series of approximately eighty-five joints which we have aspirated for culture. Of this number we have twenty-six positive joint cultures or a percentage of thirty. Of these twenty-six different organisms which we have recovered, eighteen have been streptococcus viridans, one streptococcus hemolyticus, three staphylococcus aureus, one staphylococcus aureus hemolyticus, one staphylococcus albus, and two gonococcus. These organisms have all been recovered directly from the joint fluid. All joint fluid has been put on media at the time of aspiration of the joint and the media has been placed at once in the incubator. We have in this series of twenty-six joint cultures, five cases in which the joint and gland were cultured. These cases have shown the same organism in the gland as in the joint. One case was a rather remarkable one in which we recovered the gonococcus from the joint on three occasions and from the gland on one occasion. This was a multiple chronic arthritic condition of eleven years' standing. At the time of examination the patient still had a chronic prostatitis. In addition to the joint culture work, we have been studying the cytology of the synovial fluid. We have shown that the average cell count for the positive joints is 9700 and for the negative joints 4400. The total number of cells in the positive joints is approximately double that in the negative. The differential count is sixty-two per cent. polymorphonuclears for the positive, and fifty-one per cent. for the negative, with nineteen per cent. lymphocytes for the positive and thirty per cent. for the negative. In addition to these two types of cells we also have found a great many monocytes, macrophages, and mesothelial cells.

Dr. Joseph A. Freiberg, Cincinnati, O.: Several years ago in the Children's Hospital at Boston we became interested in a series of joints in young children who had the clinical signs of early toxic arthritis. Twelve of these involved the hip joint, and they responded very quickly to a very simple type of treatment. They were put on traction and the alimentary tract was treated by the usual methods of medication, enemas, diet, and massage. It struck me at that time that these cases were interesting as demonstrating early arthritic lesions and that if there were organisms in these joints, the type of treatment would not have been satisfactory nor would it have accomplished the removal of these organisms from the joints. These cases were followed for eighteen months and had remained well.

In attempting to produce arthritis in experimental animals and in looking over the literature, I found that in numerous reports from the dysentery epidemics, which occurred during the War, there was a considerable percentage of arthritis. These arthritic lesions were not a serum arthritis but were a definite, prolonged, proliferative type of arthritis. Therefore, in producing or trying to produce a toxin, I took a strain of Flexner's dysentery organism and grew it on culture media, made a suspension in saline solution, and after allowing two weeks' time for autolysis, I filtered it through a Berkfelt filter. This filtrate was sterile. A small amount was injected into the knee joint of rabbits. It is rather interesting that there was no reaction following the first and second injections,

but following the third and fourth injections, varying in different animals, a definite lesion was produced. This lesion was characterized by effusion and periarticular infiltration. I used salt solution, horse serum, and dilute lactic acid to control the toxic joints, and in no case did I get a similar type of joint lesion. Following these rabbits, and studying the x-rays of the joints, the similarity between these joints and the type of arthritis we see in proliferative or infectious arthritis, as contrasted with the degenerative or hypertrophic type of arthritis, was quite striking. These rabbits were injected at periods of three or four weeks. There were permanent joint changes. Several of these rabbits have been sacrificed. In one it was eighteen months after the last injection, and in each case they showed the same microscopic findings as in the early part of the experimental work. There was cartilage destruction and proliferation of the synovial membrane, a small amount of effusion, and in several instances new bone formation at the site of the ligamentous attachments. It seems to me this is an arthritis which is similar to the proliferative type of arthritis in man.

Dr. Nathaniel Allison, Boston, Mass.: I want to thank Dr. Gibson for putting this problem so well before us. We have spent years trying to treat arthritis deformans without knowing what the process is. I think every kind of treatment has been used without much avail. Now at last, we have come to a point where we are trying to find out what causes these joint changes. At the Massachusetts General Hospital we have had about six out of ten successes in growing cultures taken from glands, our four failures out of ten have been due to the fact that we do not let them grow long enough. The tendency to throw things in the sink in the laboratory is very persistent. Forty-eight hours is a long time in the laboratory. These cultures have to run for several weeks before they can be called negative.

We have done synovectomies on these people and have carefully sectioned the synovial membrane. In the proliferative type of arthritis the synovial membrane is the chief tissue structure at fault. Dr. Ghormley and I have found such a characteristic picture in the synovial membrane that we can make the diagnosis by looking at the slide as you can in tuberculosis. There are small round cells arranged in focal collections. Dr. Gibson has called this type of arthritis a lymphoid type of infection. If there is so definite a tissue change, the causes must be very similar. There may, however, be one type of bacteria or there may be several types of bacteria at work in the same patient.

I would like to emphasize this simple fact, do not jump to the conclusion that because these patients improve, you have done the thing that is necessary to cure them; we find that they improve after typhoid inoculation, that they improve after what is called "amodoxyl", and that they improve a lot if you give them an anaesthetic; after anaesthesia for synovectomy, all other joints will be much better. Do not draw conclusions too quickly from the improvement which takes place after any type of vaccination or serum therapy, or in fact any other type of treatment.

Dr. Alexander Gibson, Winnipeg, Canada (Closing the discussion): I feel very much gratified at the discussion my paper has provoked. I assure you I came to your Section to try to provoke some discussion and am grateful to Drs. Baer, Allison, Osgood, and Henderson for the account of their experiences. We have all felt dissatisfied with these cases. We have tried to handle them in various ways but in the back of our minds we have felt that our treatment was unsatisfactory. In our part of the world we probably do not have the facilities for research that you have and it is a pleasure to come down here and learn.

FRACTURES OF THE ELBOW, THROUGH OR NEAR THE LOWER EPIPHYSIS OF THE HUMERUS*

BY C. F. EIKENBARY, M.D., SEATTLE, WASH.

Before the Orthopaedic Section of the American Medical Association in 1923, the writer gave a report on twenty-three cases of fracture of the elbow, occurring near or through the lower epiphysis of the humerus. The report was concerned entirely with the fracture as it occurs in children. Of these cases, the end result was definitely known in twenty-one cases. Twenty of the cases had perfect results, so far as function was concerned; one had 110 degrees of motion; the percentage of perfect functional results was ninety-five. This percentage was very high, obviously too high to continue over a very large series of cases. Since the last report, the writer has had occasion to treat thirty more cases of recent fracture, in children, occurring in the same region, bringing the total up to fifty-one. Forty-four cases have practically perfect functional results, the remaining cases having some limitation to motion, one case having no more than twenty degrees of motion; percentage of practically perfect results being about eighty-six, which is about the figure given by other writers. This percentage is about as high as we can expect to get, by any known method of treatment.

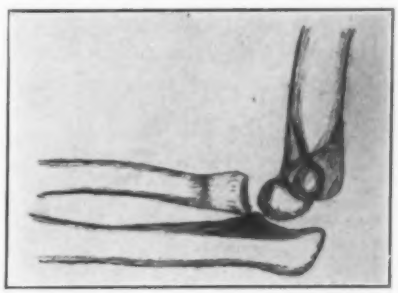

FIG. 1

Normal elbow in child of nine years. Note that the epiphysis goes downward and forward at an angle of approximately forty-five degrees.

Several points were emphasized in the former paper, which should be emphasized again. It should be almost axiomatic that the end result, or at least the rapidity with which the end result is obtained, is in direct proportion to the nicety of the reduction (Figs. 4, 5, 6 and 7). This obvious fact is all too frequently overlooked. Every poor result seen by the author either in his own cases or the cases that have been treated elsewhere, has shown a failure to obtain a good reduction, every poor result showing a posterior displacement of greater or less degree. It should be borne in mind most constantly that the lower epiphysis of the humerus points downward and forward at about an angle of forty-five degrees (Fig. 1). It does not continue in a straight line with the humerus. To leave it in a straight

*Presented at the meeting of the American Orthopaedic Association, Washington, May 1928.

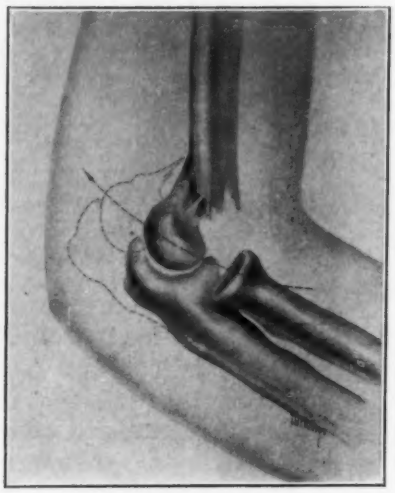

FIG. 2

Schematic illustration showing the line of force applied in the first step of attempted reduction. The lower fragment is angulated backward, thus freeing the serrated ends.

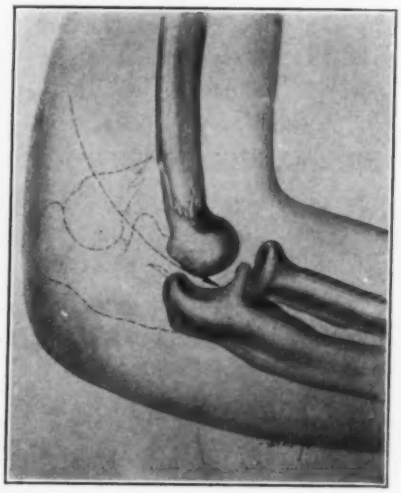

FIG. 3

Schematic illustration showing the line of force in the second manoeuver. The lower fragment, having been angulated backward, is now brought downward and forward, at the same time the elbow is acutely flexed.

line or with a backward displacement almost inevitably leads to limited motion, and not infrequently to a Volkmann's contracture.

A good radiograph should always be made before any attempt at reduction. Reduction is certainly best carried out while holding the part under the fluoroscope, and certainly always under a general anaesthetic. In lieu of the fluoroscope, another radiograph should be made before the splints are applied, and before the child comes out from the anaesthetic. If reduction is not complete, another attempt should be made.

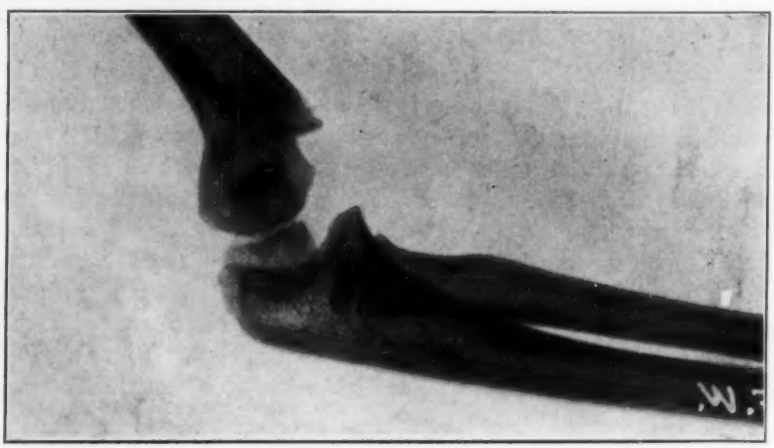

FIG. 4

Typical posterior displacement of the lower epiphysis.

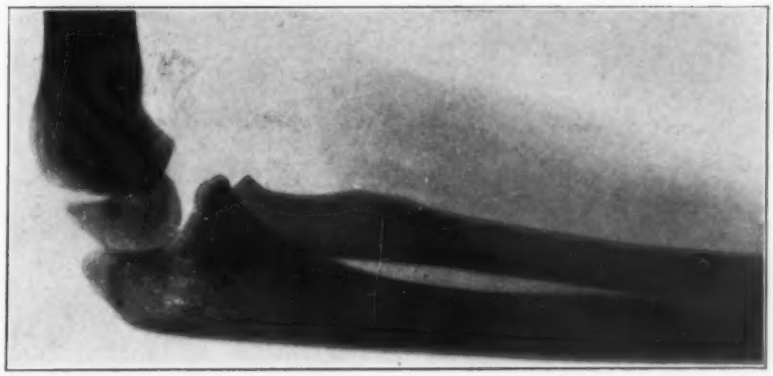

FIG. 5
Reduction practically perfect.

The statement is occasionally made that this type of fracture can be reduced by acutely flexing the forearm. This is far from the truth. Flexing the forearm, without at the same time reducing the posterior displacement, will merely rotate the lower fragment on a transverse axis. Flexion will readily hold the reduced fracture, but it will not accomplish reduction.

Reduction: The lower, posteriorly displaced fragment is practically an integral part of the forearm. Therefore, the forearm and the lower fragment, are acutely angulated backward, markedly increasing the deformity. Traction is then made downward and forward, at the same time flexing the elbow. This procedure unlocks the serrated ends of the fracture, and enables the operator to bring the lower fragment into correct anatomical position in its relationship to the humerus (Figs. 2 and 3). A similar manipulation will accomplish the lateral reduction. The elbow now being flexed, and the fracture reduced, it is retained in that position by whatever means the operator may have at his disposal. The writer uses a plaster mold, but there are various splints that will answer equally well.

FIG. 6
Note the perfect carrying angle. No physiotherapy given.

Following the reduction, and application of the splints, a point is made

FIG. 7

Perfect flexion and extension. A result in exact proportion to the nicety of the reduction.

FIG. 8

Typical Volkmann's contracture (See Fig. 9).

of insisting that the child stay in the city, preferably in the hospital, but certainly in the city, and always within easy reach of a telephone.

Volkmann's contractures are entirely too frequent, and the best way to prevent their occurrence is by being in very close touch with the child, so that the splints can be readjusted at the first warning. A few hours of neglect may lead to a condition that can never be repaired.

FIG. 9

Same case as shown in Fig. 8. Fracture never reduced.

Within a week very limited passive motion may be started, always guarded, and never to the point of causing real pain. By three weeks, the splints may be discarded, and a simple sling substituted. If possible the patient comes to the office every day, at which times the arm is allowed to be moved into extension as far as the child can do so without the production of pain. At the end of the procedure, the arm is returned to the sling, in the position of flexion. Usually the sling may be discontinued by the end of four weeks. Formerly a great deal of physiotherapy was used, but the

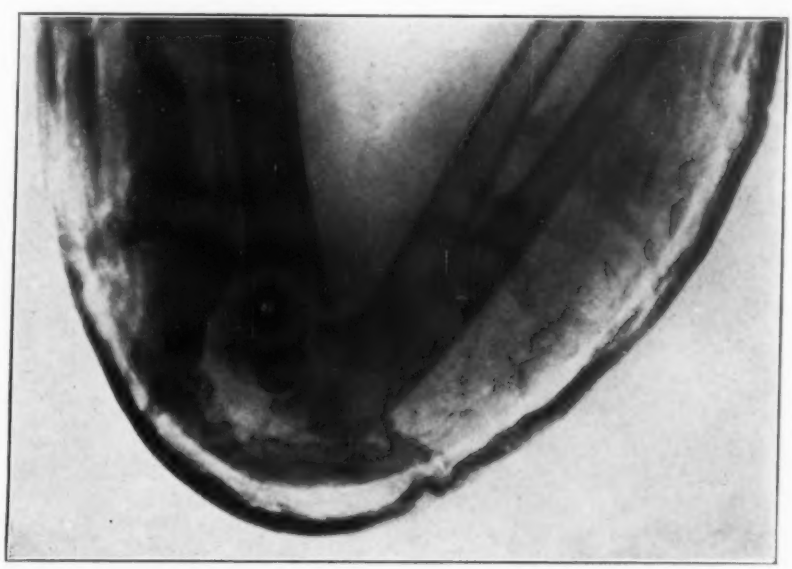

FIG. 10

A case which was put up in flexion, with fracture unreduced. Result:—Typical Volkmann's contracture. The twenty-one cases of Volkmann's contracture have all shown the same failure to reduce the posterior displacement.

writer is using less and less, and depending more and more upon the active movements of the child. Incidentally, there is absolutely no indication for forcibly moving the elbow while the child is under an anaesthetic. This treatment is probably the very worst procedure that could be carried out, and contrary to all experience and all pathology. No improvement has been made on John Hunter's statement along this line.

Within the past three years, the writer has seen twenty-one cases of Volkmann's contracture, a rather large number. As none are included in the series of recent fractures reported, it may be worth while to inquire into the findings of the twenty-one cases. Every case, *without a single exception*, has shown a persistent posterior displacement (Figs. 8, 9 and 10). Either the epiphysis has been left in a position of a straight line with the humerus, or was occupying a position somewhat posterior to the humerus. All the cases gave a history of having the arm put up in rather acute flexion, and of having a great deal of pain following the application of the splints. Is it not likely that the position of acute flexion, *with the fracture unreduced*, would seriously interfere both with the venous and the arterial blood supply—thus leading to the so called Volkmann's contracture? It would seem to me that such could readily be the case. It so happens that the writer has never seen a Volkmann's contracture as a result of any type of injury to the elbow except that of fracture of the condyles, and always with a persistent posterior displacement. Undoubtedly, a Volkmann may occur from other injuries, and undoubtedly it may occur in cases where no splints have been applied, but all the instances of Volkmann's contracture which the author has seen have been in those of persistent posterior displacement, and where the elbow has been splinted in acute flexion,—acute flexion *with the fracture unreduced*.

THE RANGE OF ACTIVE MOTION AT THE WRIST OF WHITE ADULTS

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According to Thane, 1899, "The movements of the wrist have their seat partly in the radiocarpal and partly in the intercarpal joints. Flexion is the freest movement, but a considerable amount of overextension is permitted. The hand can be moved laterally . . . and to a greater extent adducted, than abducted when in pronation." This quotation illustrates well the statements found in most anatomical texts, and those of clinicians have been no more definite. The latter usually refer merely to limitation of movement, and more rarely also to an excess of motion. Very few authors, indeed, have attempted to translate their ideas on motion at the wrist joint into degrees, and those who have done so give estimates based on casual observations rather than accurate measurements. However, Davis, 1918, wrote: "The hand can be flexed and extended through an arc of approximately 140 degrees and abducted and adducted about half as much".

According to Clark, 1920, "the normal limits for each joint . . . can only be considered as approximate, since there is a wide variation dependent on the development of the soft parts and on the habits of exercise of the different persons". Clark gives the normal range of motion at the wrist as follows:

Flexion	100 degrees
Extension	180 "
Abduction	165 "
Adduction	130 "

Rosen, 1922, used a method which has been adopted by the clinic of Functional Re-education of New York. He described it as follows: "In this system the angle formed when extreme extension is present in a joint is never made the basic angle for mensuration, nor are the various 'neutral' positions considered. The angles presented in these positions are not constant. They vary in different individuals, and also in corresponding joints of the same individual, due to structural dissimilarities which may be either physiological or pathological. The only thing that concerns us is the size of the angle subtended at the two extremes of the excursion of the joint. The difference between these two extremes gives us the range of motion, which, when compared with the normal, gives us the degree of disability present."

I found no reliable method of determining an average range of motion for the wrist joint in the literature. In my work I used the apparatus

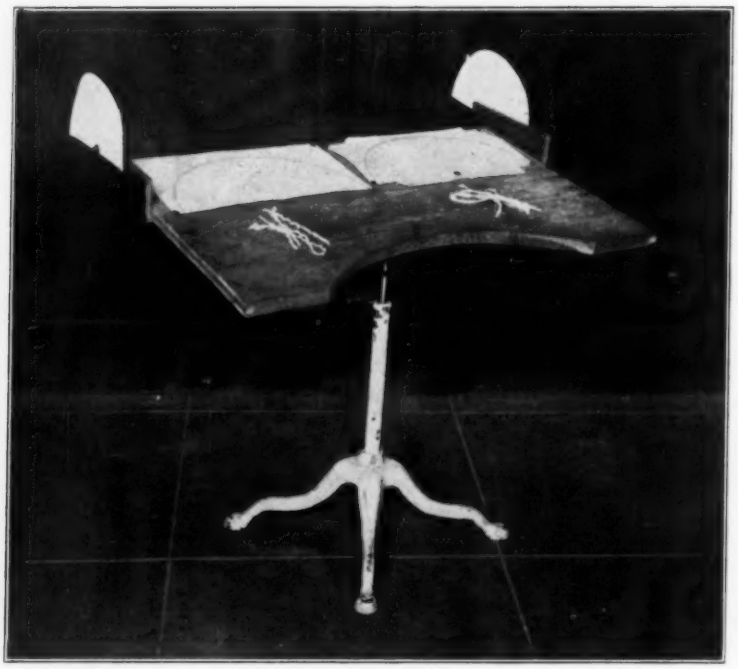

FIG. 1
The apparatus used for the measurements.

represented in Fig. 1, which was suggested by Dr. Meyer. It consists of a flat table supported by an adjustable iron rod moving in a tripod base. This table could be raised or lowered and tilted forward and backward. The table top is approximately thirty inches by sixteen inches and is hinged so that it is easily adjustable. The underside of the table is reenforced with wooden strips. The front is cut out deeply so that it can be brought closer to the subject. The ends are used for rests for the forearm when measuring dorsiflexion and volar flexion. Cloth straps were used to hold the forearm flat to the surface, but these were not tightened enough to inhibit motion at the wrist. They pass through four holes so as to form a figure eight on the forearm.

Two protractors are fastened on the flat surface, one for each hand. They are made of cardboard and shellacked so that they can be kept clean. These protractors are used for measuring abduction and adduction. They are seven inches in diameter and were found large enough for all hands encountered. The midline of the protractor marks the zero point or point of rest, and the numbering is from this zero point to the 90 degree mark on either side at the base line of the protractor. The midpoint of the baseline is marked by a colored thumb-tack and the midpoint of the radiocarpal articulation is brought over this point as accurately as possible. This enables one to keep the axes of rotation constant and to read directly

in degrees in either direction for adduction and abduction. The radial side of the third finger at the first metacarpal joint was used as indicator and a pencil mark at this place made a direct reading in degrees on the flat underlying protractors for adduction or abduction possible. The individual was asked to keep the arm and hand flat, with the midpoints of the joint and protractor coinciding. A tendency to flex the fingers during radial and ulnar flexion was noticed, in supination.

On either end of the farther side of the table, an adjustable celluloid protractor is attached so that it can be rotated in a vertical plane. By keeping the hand fixed in position and tilting the table top and the protractors, the midpoint of each wrist can be made to coincide with the point of rotation of the protractor. The range of flexion and extension was determined by means of these protractors. A five-inch protractor was found to be sufficient for this purpose. One movement at a time was measured, and the subject was asked to put all of the effort possible into each movement.

The right hand was taken first and after radial and ulnar flexion were measured, both in supination and pronation, the arms were moved out to the side of the table and the range of flexion and extension obtained. The hand projected beyond the edge of the table with the fingers extended. The midpoint of the protractor was tilted to correspond with the midpoint of the joint and the readings were then made directly. The readings were recorded on mimeographed forms such as that below. The amounts of flexion and extension in the position of supination were not determined. Only normal joints were used and wherever limitation of motion was present, special inquiry was made regarding the matter.

Name	*Age*	*Race*	*Class*	*Special Training or Occupation*	
In supination				Right	Left
	Ulnar flexion			.....	.....
	Radial flexion			.....	.....
In pronation					
	Ulnar flexion			.....	.....
	Radial flexion			.....	.....
	Dorsiflexion			.....	.....
	Volar flexion			.....	.....

My measurements included one hundred college men and fifteen women in the second and third decades of life, with approximately the same physical activities at the time of measurement. The average results are given in Table 1.

Humphreys, 1858, wrote, "There is no instance in which the movements of a joint are stopped or limited by the shape of the bones,—that is by the edges of the bones coming in contact. . . . . The tension of the ligaments or the compression of the soft parts arrests the movement before the margins of the bones touch each other", but according to Cunningham, 1919, "the styloid process of the radius interferes with abduction". That

TABLE 1

AMPLITUDE OF MOTIONS AT THE WRIST

Men, 100—Women, 15

SUPINATION

		Right		*Left*	
		Men	Women	Men	Women
Ulnar Flexion:	Average	61.5	66.3	56.3	60.7
	Maximum	88.0	82.0	88.0	83.0
	Minimum	43.0	52.0	20.0	43.0
Radial Flexion:	Average	26.9	30.8	32.2	35.9
	Maximum	68.0	54.0	62.0	49.0
	Minimum	7.0	12.0	12.0	14.0
Range of combined movements:	Average	88.2	95.8	89.0	96.6
Individual	Maximum	131.0	135.0	127.0	128.0
Individual	Minimum	66.0	72.0	56.0	68.0

PRONATION

		Right		*Left*	
		Men	Women	Men	Women
Ulnar Flexion:	Average	32.8	37.2	33.6	34.8
	Maximum	65.0	78.0	58.0	58.0
	Minimum	10.0	22.0	18.0	24.0
Radial Flexion:	Average	43.4	50.9	44.4	48.8
	Maximum	77.0	75.0	71.0	59.0
	Minimum	22.0	36.0	21.0	24.0
Range of combined movements:	Average	77.0	94.3	79.0	91.8
Individual	Maximum	116.0	114.0	122.0	112.0
Individual	Minimum	44.0	73.0	53.0	68.0
Dorsiflexion:	Average	66.4	71.0	70.0	76.6
	Maximum	92.0	95.0	90.0	95.0
	Minimum	38.0	31.0	40.0	50.0
Volar Flexion:	Average	80.4	84.6	81.3	80.2
	Maximum	99.0	96.0	95.0	94.0
	Minimum	52.0	72.0	61.0	67.0
Range of combined movements:	Average	133.0	155.0	154.5	160.0
Individual	Maximum	176.0	178.0	177.0	184.0
Individual	Minimum	107.0	127.0	123.0	126.0

FIG. 2

Skiagram of the right hand in radial flexion in the position of supination.

FIG. 3

Skiagram of the right hand in ulnar flexion in the position of supination.

the latter is the case in some positions, can be seen in Figure 2, which is a skiagram of a right hand in supination and marked radial flexion. In this skiagram the styloid of the radius seems to be in direct contact with the greater multangular bone in the position of supination with the wrist in marked abduction. This does not seem to be the case with the wrist in ulnar flexion in the position of pronation, however, even when the amplitude of the movement is large. This is illustrated by the skiagram of the right hand in Figure 3. In this instance the ulnar styloid lies in a triangular space between the pisiform and triquetrum. In Figure 4, however, which is a skiagram of a left hand in the same position, the ulnar styloid seems to be in contact with the triquetrum and this contact may have been responsible for the small amount of ulnar flexion which was present in this hand.

As seen in Table 1, the average range in every motion in men, except that of ulnar flexion, in the position of supination, is greater in the left than in the right hand. This is a very peculiar thing and I hardly know how to account for it, although the same thing is true of this movement and of radial, ulnar and volar flexion in the position of pronation, in women. That is, in women, only radial flexion in supination and dorsiflexion in the position of pronation are somewhat larger in amplitude on the left than on the right. However, since the number of women is so small, and the difference between the averages slight, it probably is unjustifiable to regard this as a sex difference. It is also possible that a still larger series of men might give different results for them.

According to Mosher, 1918, "Wrist flexion is found to be 0.55 per cent. and extension 0.25 per cent. greater in the woman as compared to the per

cent. of distribution in the man. This is readily explained by the constant, small movements in sewing, knitting, etc., which form a large part of woman's occupation. Piano playing also is probably more frequent in women than among men." It is difficult to conceive of any method of measurement so accurate that such small differences as those given by Mosher could be regarded as intrinsic and it seems exceedingly doubtful that the relatively slight movements necessary in most of the occupations mentioned could increase the amplitude of motion. It would seem much more likely that the heavier occupations of men result in a limitation of motion. That this inference may be correct is suggested by the fact that all the movements except one have a greater amplitude on the left than the right in men.

In my series of measurements the differences between the sexes, in the amplitude of the movements of extension (dorsiflexion) and flexion (volar flexion), at the wrist, were considerably greater than those given by Mosher. Dorsiflexion was 4.6 degrees greater in the right hand of women and 6.6 degrees in the left, and volar flexion was 4.2 degrees greater on the right but 1.1 degrees less on the left. Reduced to percentages of the average amplitudes of dorsiflexion and volar flexion in men the movements of dorsiflexion and volar flexion on the right and of dorsiflexion on the left were approximately 7, 9 and 6.5 per cent. greater in women, but volar flexion 1.3 per cent. less. If averaged for the two hands, the movement of dorsiflexion would be 7 plus instead of 0.55 per cent. greater in women. That is, I found the sexual differences twelve times as great on the right in the movements of dorsiflexion and volar flexion in women, and that of dorsiflexion, in the left hand, thirty-six times as great, but that of volar flexion in the left hand of women actually less than that in men. This may be due to the small number of women in my series, and since I do not know upon how large a number Mosher's statement was based, I cannot compare them.*

The amplitude of all movements, except that of volar flexion of the left hand, is larger in women than in men. This again is a very peculiar result and needs further investigation before it is profitable to try to analyze it, except to say that since the amplitude in this motion is only 1.1 degrees less in women than in men, it may be due to the small number of women in the series.

Since the average age of the women was 22.8 years and that of the men 23.5, it is very improbable that the apparent sexual differences observed were due to difference in age. The excess of motion in women over that in men ranges from 1.2 degrees in ulnar flexion in pronation to 6.6

*Miss Hewitt found dorsiflexion 2 degrees greater in the right hand of women and 3.5 degrees in the left, but volar flexion was 0.2 degrees less on the right and left. The movement of dorsiflexion in women was approximately 3 per cent. and 5 per cent. greater on the right and left respectively, but volar flexion was 0.2 per cent. less on both the right and left. If averaged for the two hands, the movement of dorsiflexion would be 4 plus per cent. greater in women, instead of 0.55 per cent. as given by Mosher. Although this is a difference of only 3.5 per cent., it nevertheless is seven times the sexual difference given by Mosher.—*A. W. M.*

degrees in dorsiflexion in pronation. It is interesting, however, that the extremes of motion usually are greater in men.

The greatest amplitude of individual movements in the two hands in men is almost the same, the difference being only about 6 degrees in several of the movements, but it is 20 degrees in some movements in women. The least amplitudes of individual movements differ from 1 degree to 23 degrees in the case of men, and almost that much in women.

The average amplitudes of radial and ulnar flexion in the two hands of women are nearly the same in the positions of supination and pronation. The average amplitudes in all movements in the two hands of men agree quite closely, except in radial flexion in the position of supination. In the latter there is a difference of 5.3 degrees. In women, the greatest difference in amplitude is 5.6 degrees.

As shown in Table 1, the left hand of men possesses somewhat greater average range than the right, both in pronation and supination in all movements, the differences being 0.8, 2.0 and 21.5 degrees. In women, on the other hand, the total average range of motion was greater on the right in radial and ulnar flexion in pronation, the excess being 3.5 degrees.

The maximum amplitude for dorsiflexion in pronation was 95 degrees in both hands of women, the minimum being 31 degrees in the case of a right hand. In men, the maximum amplitude in the same position was 92 degrees and the minimum 38 degrees, both in the right hand. The maximum for volar flexion in pronation in the case of women was 96 degrees in the right, while the minimum was 67 degrees in the left. In men, in the same position, the maximum was 99 degrees and the minimum 52 degrees in a right hand.

FIG. 4

Skiagram of the left hand in the same position.

FIG. 5

Skiagram of the right hand in volar flexion in the position of pronation

TABLE 2

MEASUREMENTS ON 100 MEN

No.	SUPINATION				PRONATION				PRONATION			
	Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1	75	68	18	44	62	47	38	53	65	81	82	90
2	53	20	68	62	51	30	60	32	76	75	89	92
3	48	50	26	33	29	31	31	39	59	72	80	84
4	88	81	28	28	41	42	75	68	74	66	85	75
5	76	85	12	30	30	31	77	70	68	76	93	94
6	60	62	37	47	35	36	42	51	73	84	88	89
7	53	56	28	35	31	33	40	46	72	80	78	82
8	57	64	35	43	27	42	50	51	66	80	87	86
9	59	56	20	33	44	46	57	35	79	90	70	68
10	54	46	22	32	30	32	36	29	62	61	83	81
11	81	79	50	48	65	58	47	51	38	40	85	93
12	67	66	24	30	52	37	32	43	45	60	92	86
13	44	46	27	31	27	34	45	32	71	68	70	65
14	66	55	28	38	32	42	31	44	61	64	84	92
15	57	52	27	30	24	27	38	41	64	69	83	82
16	71	74	14	14	12	26	36	33	49	57	82	92
17	75	67	16	21	14	24	57	49	76	75	78	75
18	53	56	18	28	24	22	50	45	52	50	70	80
19	59	61	36	31	29	28	51	44	58	58	78	71
20	68	54	7	16	20	22	37	31	49	62	87	89
21	63	52	32	26	42	41	37	27	69	72	79	76
22	72	78	16	17	29	32	44	51	63	76	87	92
23	58	59	31	34	31	31	47	68	68	73	86	85
24	57	51	27	36	29	41	40	31	67	76	86	88
25	52	46	18	33	23	31	43	42	83	76	79	77
26	69	52	26	31	34	37	51	45	55	61	85	84
27	53	62	16	20	26	28	36	35	64	76	63	73
28	57	60	22	26	25	21	39	42	79	79	80	86
29	72	60	27	25	41	24	41	44	62	68	86	82
30	64	53	26	29	34	26	35	46	58	60	70	81
31	73	62	44	35	40	38	47	53	71	68	76	76
32	57	56	18	26	37	34	40	44	74	78	80	85
33	66	60	19	26	38	33	31	50	85	79	72	73
34	79	88	38	34	58	51	52	71	70	62	92	89
35	71	76	26	17	24	18	52	53	74	86	89	80
36	63	58	20	20	10	29	35	46	51	68	82	88
37	67	82	29	29	40	37	43	38	72	72	92	85
38	56	55	17	22	20	32	52	48	72	66	70	76
39	67	70	45	42	44	36	46	49	82	81	84	92
40	52	56	27	39	35	35	42	51	78	73	78	76
41	63	58	18	35	35	25	52	52	86	71	72	72
42	73	66	40	29	58	58	41	33	58	64	86	92
43	73	69	28	27	30	26	64	65	72	84	70	82
44	69	29	26	60	34	31	40	21	65	55	70	78
45	59	66	42	45	37	24	47	50	65	73	89	92
46	53	56	17	24	24	30	44	37	61	69	72	73
47	47	44	15	12	19	45	25	33	76	78	52	70
48	62	35	35	54	45	37	37	39	62	84	99	89
49	64	65	26	38	34	48	55	56	46	55	89	88
50	53	50	25	22	35	34	30	36	68	70	70	78
51	61	55	16	31	29	30	36	23	70	74	82	80
52	71	67	22	25	32	32	46	44	66	81	81	76
53	68	21	31	62	20	41	48	35	56	64	93	93
54	71	35	30	62	41	42	42	32	75	70	87	82
55	68	72	44	33	43	52	59	58	72	66	84	75
56	50	47	27	38	27	27	37	46	92	86	63	74
57	63	55	26	27	23	34	40	46	65	70	64	76
58	52	46	24	30	27	36	46	48	74	66	82	86
59	60	56	26	35	41	27	42	47	59	73	86	82

TABLE 2 (cont.)

No.	Supination				Pronation				Pronation			
	Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*	
	Right	Left	Right	Left	Right	Left	Right	Left	Righ	Left	Righ	Left
60	56	46	17	23	21	24	31	45	61	69	96	95
61	63	61	28	23	38	35	41	46	82	87	93	82
62	63	56	41	41	42	53	49	51	62	63	93	94
63	65	72	24	36	32	24	60	53	58	60	86	76
64	67	59	22	23	24	27	39	45	64	78	76	73
65	76	57	30	32	21	36	58	54	60	76	82	90
66	50	39	36	27	24	25	37	45	74	66	81	70
67	43	35	31	47	30	45	31	28	49	61	58	62
68	53	52	21	24	33	30	45	49	62	67	85	82
69	53	51	26	31	29	35	34	36	63	61	81	86
70	53	47	18	36	22	30	34	41	59	60	69	73
71	46	43	22	31	35	37	22	37	73	71	69	70
72	69	61	26	37	31	31	41	50	64	59	83	84
73	66	75	26	32	33	40	60	56	65	72	81	86
74	65	60	22	31	32	36	46	41	76	75	81	82
75	61	48	28	42	20	22	34	44	55	54	78	85
76	45	57	39	47	40	36	46	58	63	54	79	76
77	58	59	27	37	37	46	34	29	62	69	80	88
78	62	51	36	31	29	35	42	45	65	78	86	89
79	57	62	27	25	29	34	37	45	76	78	79	72
80	73	66	56	29	36	26	45	42	68	56	80	89
81	59	71	35	42	57	45	47	52	78	76	86	89
82	59	56	30	39	37	34	41	50	66	65	73	80
83	60	20	11	18	19	22	50	47	74	74	86	89
84	68	50	35	37	45	32	50	50	79	81	81	74
85	56	37	43	30	45	37	38	32	66	67	82	80
86	50	37	16	43	25	26	29	38	59	76	78	72
87	59	56	24	43	39	42	34	44	64	65	58	74
88	43	42	16	31	23	37	45	36	62	66	66	75
89	66	60	15	27	27	27	40	48	63	74	78	61
90	86	66	43	49	59	45	54	53	76	72	95	80
91	53	54	20	22	25	25	41	39	62	69	78	79
92	56	54	18	22	27	29	47	46	73	82	86	78
93	72	63	37	33	42	36	64	46	67	66	90	87
94	57	50	22	16	25	22	28	41	70	62	79	75
95	67	60	12	19	25	26	44	47	61	64	80	78
96	64	52	30	20	29	27	36	39	46	55	78	82
97	55	56	12	18	24	26	46	45	63	82	76	74
98	52	62	34	33	26	35	41	44	72	73	86	79
99	51	43	21	26	24	19	48	43	73	75	82	86
100	57	53	30	37	42	39	34	41	64	66	72	82

In the position of pronation, the maximum amplitude of radial flexion was 77 degrees in a right hand, and the minimum 21 degrees in a left hand of men. The figures for women were 75 degrees, right, and 24 degrees, left. The movement of ulnar flexion, in the position of pronation, had a maximum amplitude of 65 and a minimum of 10 degrees in the right hand of men. In women it was 78 degrees and 22 degrees respectively.

In the position of supination, the maximum amplitude of radial flexion was 68 degrees and the minimum 7 degrees in a right hand of men. The same results for women were 54 degrees and 12 degrees on the right. The maximum for ulnar flexion was 88 degrees in both hands of men, and the minimum 20 degrees for a left hand. In women these amplitudes were maximum 83 degrees and minimum 43 degrees, in the right hand.

Scrutiny of the tables (Tables 2 and 3) of measurements will reveal the existence of amazing differences in the amplitude of the same movement, in the same individual, in the position of pronation in contrast to that of supination. At first sight this difference may seem to be due to some defect in the apparatus or to carelessness on the part of the observer or the individual measured, but repeated measurements of the same motion on the same person indicate that none of these things need be true. I discovered great fluctuations in successive measurements in individuals who cooperated to the fullest extent and who had a thorough understanding of the purpose and significance of the measurements. All individuals were university students and approximately one-half of them were students of medicine.

This experience seems to indicate that a single measurement of any movement does not afford much of an indication of the true amplitude, even in a normal wrist joint. It probably would be a still poorer indication in case of an affected one. The unreliability of single movements probably is due to the fact that we seldom try to execute movements of maximum amplitude at the wrist, and that hence none of these movements is under sufficient control when a maximum effort is asked. Moreover, since the range of the usual motions is slight and hence not limited by bony contact, much depends upon the effort made by the individual against hindrances due to the ligaments and tendons. According to Bryce, 1897, volar flexion is limited "by the contact of the pisiform and the head of the ulna". This well may be the case in extreme flexion, but one apparently cannot depend upon the individual always to realize the fullest amplitude possible in this movement. For if bony contact is responsible for the limitation, it would be expected that the same amplitude would be achieved in successive movements.

TABLE 3

MEASUREMENTS ON 15 WOMEN

No.	SUPINATION				PRONATION				PRONATION			
	Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1	72	54	35	45	41	24	42	52	78	76	86	78
2	63	60	13	28	37	32	50	36	55	50	72	76
3	82	83	38	37	78	58	36	24	95	95	83	89
4	59	61	13	14	35	27	51	41	31	52	90	83
5	68	43	22	49	41	32	42	59	84	76	82	83
6	81	79	54	49	47	58	75	52	76	89	78	67
7	64	45	50	49	47	51	56	55	62	85	96	91
8	63	63	26	38	26	32	50	57	79	76	87	92
9	69	67	47	45	32	35	63	56	54	69	92	89
10	70	67	22	28	22	27	56	52	77	87	86	94
11	63	61	28	24	22	30	51	48	82	80	82	86
12	65	65	32	37	33	27	60	53	73	86	84	79
13	63	57	44	38	32	30	43	52	72	72	83	77
14	52	50	27	18	30	25	43	45	68	86	76	80
15	61	56	12	39	37	30	46	51	76	70	92	89

The skiagram shown in Figure 5 seems to show contact of the pisiform and the styloid of the ulna, for the shadows of the two overlap. However, it must be borne in mind that this fact is not an absolute proof of the presence of bony contact. The skiagram is of the right hand in volar flexion in the position of pronation. It does not seem to me, however, that there was bony contact between the two, for there is no displacement of the shadow of the pisiform on the triquetrum such as might be expected if the styloid had been forced against the pisiform. It should be added, however, that there was a low amplitude of volar flexion in this hand. However, if the maximum amount of amplitude possible in it was obtained, then apparently volar flexion is not limited by contact of the pisiform and styloid in all cases.

In view of these considerations, only average measurements can have much value and I should not regard a difference of 5 degrees of much significance, unless it represented a progressive increase or decrease in motion or the difference between the averages of a large series on the same or on different individuals. It also seems likely to me that it is necessary to use persons of approximately the same age and occupation, but these are matters for further investigation.

I take pleasure in thanking Dr. Meyer for suggesting the topic for investigation and for much aid in the preparation of this article.

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THE RANGE OF ACTIVE MOTION AT THE WRIST OF WOMEN

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This study was undertaken to determine the extent of motion at the wrist in adduction, abduction, extension, and flexion, in both supination and pronation, in a group of college women and high school girls. The age and training, and any condition that might affect the freedom of motion, were recorded.

The phrase "limitation of motion" is frequently used clinically, and such a study hence has a practical aspect, particularly with reference to workmen's compensation following injury. The wrist joint is one which is frequently injured in industry, and since it is considered the most highly specialized and highly trained joint in the body, it seemed reasonable to believe that it would be of special interest, as well as practical value, to obtain the average extent of motion in terms of degrees, by means of systematic measurements.

Although a number of studies have been made of the anatomy and mechanics of the wrist joint, most of these consider the mechanics (Fick, 1904), or the angulation between the various wrist bones (Virchow, 1911 and Bell, 1833). Rosen, 1922, worked out a simple method for roughly measuring most of the joints of the body with calipers, but this at best is a rough clinical method and the values obtained cannot be compared with the normal or average range as long as the latter remains unknown. Clark, 1920, gave a rough average for some of the joints. Those he gave for the wrist in supination are as follows: adduction 50 degrees, abduction 15 degrees, extension 60 degrees, and flexion 80 degrees. Bryce, 1896, considered different possibilities by simple methods of measurements of the wrist joint.

In my series, the individual was placed at the table shown in Figure 1. This was constructed so that it could be adjusted to the proper height for the comfort of each person. For the movements of adduction and abduction, the forearms were placed on the pads *C* (Fig. 1) with the center of the wrist over the point *G*. They were then strapped securely by means of cloth straps with metal buckles, adjustable for any size. For the measurement of extension and flexion, the arms were placed against the boards carrying the protractors *E*, with the radiocarpal joint opposite *H*. The observer sat on the opposite side of the table and kept one hand lightly on the forearm, the wrist of which was being measured, in order to guard against any slight motion that might otherwise not have been observed. The individual was asked to hold the forearm motionless with the elbow

flat on the table. During extension and flexion, the arm was not strapped down, but was held flat on the table and against the board on the side.

The hand always was placed in a straight line with the forearm, for measurements of adduction and abduction, and the protractor placed so that the zero point fell between the middle and ring fingers. The final reading was taken between the same fingers at the end of motion. For measuring extension and flexion, the adjustable protractor *E* was adjusted so that the zero mark was in a horizontal line with the upper surface of the board at the radiocarpal articulation and the readings taken from the upper surface of the hand.

Before taking the measurements, the name, age, school year, right- or left-handedness, and nationality were recorded upon the blank form given below. Any history of injury of the wrists was noted, and any training of sufficient duration so that it might have developed or trained the muscles of the wrist, such as piano-playing, sports, typewriting, etc., was also noted.

Name *Age* *Race* *Class* *Special Training or Occupation*

		Right	Left
In supination			
	Adduction	——	——
	Abduction	——	——
In pronation			
	Adduction	——	——
	Abduction	——	——
In supination			
	Extension	——	——
	Flexion	——	——
In pronation			
	Extension	——	——
	Flexion	——	——

The readings were then taken twice for each direction and if they differed more than 5 degrees, the movement was repeated until the difference was within that range. When within 5 degrees, the greatest angle was recorded. Care was taken to keep the fingers together and on a level with that of the metacarpals in adduction and abduction. If the fingers had left this plane when the maximum motion had been completed, the observer fixed the hand by holding it and returned the fingers to the desired position, before the readings were taken. The latter always were taken in the same order, beginning with the right hand, taking adduction (ulnar flexion) and abduction (radial flexion) in pronation and then in supination. The same movements were then taken of the left hand. Measurements of the right hand in extension (dorsal flexion) and flexion (palmar flexion) were then taken in pronation, and these were followed by the same measurements in supination. The same motions were then measured on the left wrist.

These measurements were made on three groups: (1) medical students and (2) students in physical education at Stanford University, and (3) girls of high school age and their advisors, at the Los Angeles Y. W. C. A.

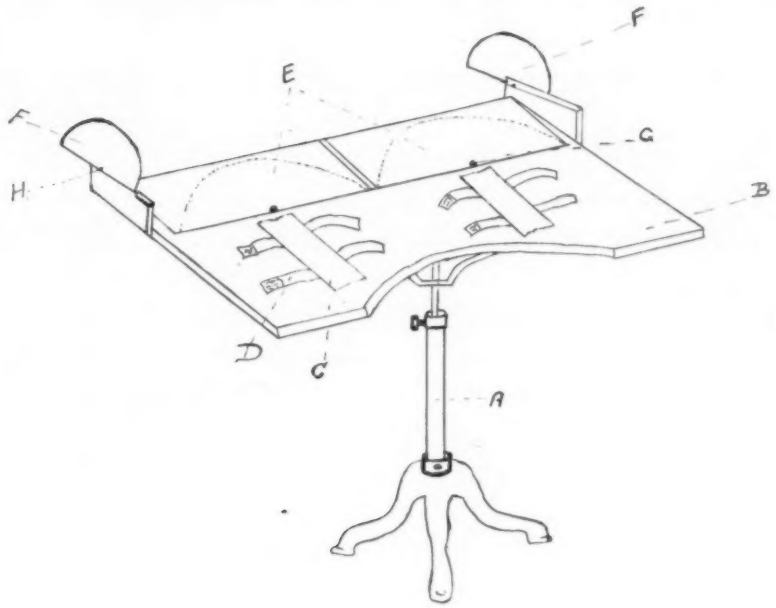

FIG. 1

A: Adjustable iron stand.
B: Wooden top.
C: Pad rest for forearm.
D: Straps for forearm.
E: Protractors for adduction and abduction.
F: Protractor for flexion and extension.
G: Center lying under wrist.
H: Center opposite axis of rotation.

summer camp. The ages in these groups ranged from eleven to forty-five years, with the largest number (68) falling between the ages of sixteen and twenty years. The average for all measurements was obtained for the groups as a whole (Table 1), and the entire number measured were divided into four groups according to age. The following numbers were in each of these groups respectively: seventeen in the 11–15 year group, sixty-eight in the 16–20 year group, nineteen in the 21–25 year group, eight in the group of 25 years and over. The 16–20 year group was then subdivided into two groups, those attending high school and those attending college, and the averages for each group determined.

Although every care was taken, an allowance must be made of about 5 degrees for error in any reading. It was found that repetition of a particular movement did not increase the range or the accuracy with which it was made, but if there was only an hour's time between readings, there were decided variations which were irregular and often more than 5 degrees.

In order to test the method and apparatus and acquaint myself with the routine, I measured the same movements in the same six students on successive days. Although the wrists all were normal, and although the

TABLE 1*

MEASUREMENTS ON 112 WOMEN

	SUPINATION				PRONATION				SUPINATION				PRONATION			
	Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*		*Extension*		*Flexion*	
No.	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1	48	50	25	15	28	31	28	24	50	75	74	80	84	80	88	90
2	60	69	40	36	37	28	30	45	62	63	72	70	72	73	75	91
3	63	70	31	37	32	41	30	24	67	70	55	55	73	80	73	80
4	49	59	49	50	22	34	39	35	46	46	70	66	70	70	83	83
5	52	48	21	34	47	40	23	34	75	69	69	71	77	77	86	84
6	39	35	27	35	51	31	30	25	60	62	60	33	62	70	52	87
7	81	85	52	70	49	55	38	37	47	50	72	70	83	70	72	85
8	76	67	47	37	49	37	40	25	81	81	74	75	77	83	84	80
9	61	70	52	39	35	39	28	28	78	70	64	80	67	73	89	92
10	70	68	38	24	60	50	28	24	85	89	72	95	74	94	92	92
11	74	76	30	27	46	48	31	43	75	81	71	66	62	85	95	83
12	48	42	34	25	76	55	33	30	68	60	79	71	76	74	90	90
13	85	75	59	65	45	40	45	32	78	96	80	88	95	90	90	88
14	79	75	45	60	65	66	32	39	66	78	72	50	66	68	88	85
15	76	78	45	58	61	53	39	40	87	70	84	90	94	86	99	106
16	56	64	46	39	45	52	39	43	65	84	88	75	81	81	89	89
17	60	66	31	38	38	43	41	40	70	63	78	65	77	62	86	87
18	72	75	46	33	47	50	40	38	65	72	74	73	75	77	99	97
19	51	65	42	31	37	35	30	40	91	58	53	82	71	42	49	81
20	75	69	39	28	68	49	23	31	80	83	78	84	88	90	88	88
21	67	71	48	39	46	47	29	25	74	66	90	97	81	95	95	89
22	68	73	35	26	52	55	33	32	68	59	70	78	61	70	75	78
23	52	64	44	34	54	41	34	30	66	68	64	73	68	77	73	85
24	76	71	45	29	59	47	36	36	65	72	51	60	75	75	65	80
25	55	62	42	21	55	49	20	22	79	84	80	82	89	98	74	70
26	50	60	42	25	46	35	29	21	74	64	88	76	60	78	80	76
27	85	77	35	35	58	52	31	39	62	63	62	75	62	62	93	94
28	88	65	53	50	53	46	42	25	67	71	74	77	62	73	99	92
29	62	38	54	37	44	39	41	35	65	73	77	84	49	63	97	76
30	74	60	62	51	54	45	50	35	63	73	57	78	70	71	80	80
31	68	49	35	21	38	33	40	43	54	43	83	77	40	50	95	75
32	67	74	48	51	58	43	55	59	31	53	80	89	80	58	83	83
33	55	60	43	49	41	46	36	36	64	52	67	77	50	82	84	76
34	71	64	40	47	60	61	31	34	72	65	78	78	73	67	95	90
35	77	65	28	20	55	43	25	30	83	71	65	63	71	80	87	80
36	58	60	25	29	40	35	37	30	80	76	65	60	68	90	94	82
37	75	77	32	34	50	53	35	30	63	50	71	77	65	60	86	77
38	85	80	52	23	65	57	32	20	83	70	79	70	94	80	83	90

TABLE 1* (Con't)

38	85	80	52	23	65	57	32	20	83	70	79	70	94	80	83	90

TABLE 1* (Con't)

MEASUREMENTS ON 112 WOMEN

	Supination				Pronation				Supination				Pronation			
	Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*		*Extension*		*Flexion*	
No.	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
39	48	48	39	35	38	25	32	28	68	46	59	68	65	73	75	82
40	63	75	30	34	52	46	38	41	63	55	60	71	45	58	95	98
41	63	71	29	35	45	45	25	22	57	57	57	50	62	67	68	60
42	68	61	23	25	50	43	28	42	76	82	88	75	70	87	91	92
43	51	56	34	30	36	35	35	35	62	58	59	49	60	78	62	73
44	62	52	26	35	25	18	44	32	53	80	58	77	78	76	90	87
45	55	58	31	24	42	42	21	23	80	80	101	116	83	80	102	105
46	62	43	16	17	24	21	39	37	46	60	55	53	62	58	87	87
47	56	65	22	20	23	15	38	32	50	45	56	50	66	68	80	68
48	73	78	29	23	27	25	48	49	67	55	66	72	94	90	93	86
49	60	55	32	25	22	27	53	45	60	53	60	51	55	63	65	66
50	52	52	18	20	20	18	41	45	65	70	65	75	85	72	72	72
51	71	65	20	39	29	26	48	53	62	65	85	77	68	84	92	90
52	61	67	20	23	30	26	45	44	58	61	74	70	70	70	73	88
53	61	65	37	24	24	26	44	51	75	62	70	80	80	95	89	83
54	56	50	26	21	26	26	42	54	63	76	60	53	55	68	60	61
55	45	46	15	21	28	20	21	34	34	45	40	38	59	52	55	76
56	60	72	11	18	21	28	55	52	68	71	75	65	82	90	82	95
57	65	60	22	30	30	30	40	48	63	64	75	74	68	68	70	66
58	67	61	23	28	29	27	37	42	63	67	78	63	61	69	78	72
59	75	71	51	51	42	33	42	43	78	73	99	98	78	85	93	89
60	65	82	20	20	22	27	42	52	53	54	61	63	60	60	64	62
61	73	73	30	35	28	25	50	51	50	55	62	62	68	66	70	71
62	63	65	20	20	18	22	42	54	62	68	53	64	64	75	83	88
63	70	56	13	20	27	22	43	51	51	70	78	73	63	71	68	82
64	79	69	31	37	31	23	51	53	72	68	64	68	68	78	92	91
65	66	61	21	15	18	15	50	46	71	68	65	63	81	72	77	83
66	69	52	12	18	23	24	50	45	78	72	44	54	68	78	75	66
67	48	44	23	28	35	33	25	36	64	66	71	73	79	99	68	67
68	50	57	25	26	17	31	38	38	52	55	58	47	58	60	70	80
69	55	45	17	18	13	17	41	33	47	45	65	48	44	52	82	69
70	62	62	10	18	24	22	41	52	65	76	65	74	84	89	68	70
71	36	40	22	21	30	26	20	35	82	56	65	61	70	75	73	83
72	51	42	12	17	18	20	30	27	44	35	74	67	58	71	61	70
73	48	47	10	18	13	15	40	44	54	72	64	57	57	71	78	82
74	54	52	9	8	11	13	44	41	73	73	48	43	81	88	58	67
75	62	72	28	18	22	26	46	54	67	73	75	76	70	73	86	77

TABLE 1* (Con't)

MEASUREMENTS ON 112 WOMEN

No.	SUPINATION				PRONATION				SUPINATION				PRONATION			
	Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*		*Extension*		*Flexion*	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
76	66	63	21	24	25	22	48	47	56	48	67	36	68	58	53	57
77	62	58	18	22	29	27	46	45	46	64	58	75	57	78	77	79
78	64	68	26	27	26	25	41	45	53	44	82	50	52	51	90	87
79	47	51	5	16	15	18	32	38	40	58	82	79	62	67	80	90
80	71	72	18	25	20	28	40	36	62	54	63	77	67	74	83	84
81	87	72	20	16	22	30	45	50	66	56	68	42	62	66	90	93
82	66	60	33	31	36	34	56	50	63	81	85	68	81	75	72	79
83	70	66	16	15	22	36	54	53	62	70	79	68	67	82	82	75
84	76	68	14	15	23	12	38	56	70	92	66	81	78	89	93	88
85	68	66	25	24	31	21	43	52	72	64	83	76	70	90	75	66
86	58	47	10	10	9	16	41	40	67	50	57	67	48	60	71	67
87	62	52	10	16	21	12	40	35	68	66	82	72	78	87	82	75
88	56	62	11	17	18	18	39	37	52	62	58	63	52	69	78	77
89	47	47	16	20	25	13	23	30	70	67	83	67	70	72	80	97
90	59	56	20	26	22	21	26	36	48	53	56	31	53	53	72	76
91	67	61	4	8	21	22	38	49	57	72	75	72	52	70	78	83
92	61	65	27	21	26	33	58	50	73	68	93	90	78	85	80	97
93	68	60	20	33	30	24	49	53	63	79	79	78	70	84	81	92
94	67	57	19	28	30	34	34	40	46	52	61	59	59	59	70	67
95	52	58	20	32	25	29	33	41	50	47	77	81	52	61	82	79
96	65	53	30	30	34	34	44	42	67	56	71	68	64	60	79	73
97	61	53	10	16	19	19	39	42	83	77	79	55	76	89	89	80
98	59	49	7	13	9	16	47	41	63	60	78	57	54	80	77	80
99	66	67	18	17	23	22	47	49	86	87	78	53	98	89	74	74
100	55	65	21	20	19	25	35	48	43	54	67	62	54	63	78	88
101	60	63	18	17	15	15	42	45	67	70	70	68	75	70	75	78
102	64	56	27	40	39	36	40	40	67	73	62	68	77	85	86	84
103	61	68	15	16	17	20	39	58	70	65	47	69	64	70	90	88
104	59	61	24	30	38	30	30	32	47	52	83	66	65	69	82	83
105	53	45	10	11	18	23	40	32	60	51	60	58	50	63	70	62
106	61	55	17	31	20	29	42	45	63	63	70	62	50	63	85	85
107	47	60	10	8	11	15	37	34	68	59	47	52	79	70	53	66
108	61	54	10	21	15	19	52	35	83	80	61	77	84	84	87	87
109	46	36	12	16	18	18	49	40	51	46	49	38	69	85	64	60
110	72	52	7	21	17	21	56	50	57	55	67	63	60	50	90	92
111	56	56	9	4	20	13	35	41	63	57	48	33	68	68	68	73
112	43	52	10	33	13	32	28	41	45	67	89	80	33	58	94	91

*I have retained the terms adduction and abduction and flexion and extension in the tables because they are shorter.

young women concerned were medical students and friends who not only fully comprehended the purpose of the measurements but cooperated willingly, the results fluctuated in an amazing way, as shown in Table 2. The greatest fluctuation sometimes was over 100 per cent. of the smallest amplitude of a particular motion, and had I not been interested especially in this matter and given it special attention, I would have concluded that these fluctuations were due to error on my part or to defects in the apparatus. The greatest fluctuations occurred in adduction and abduction in both supination and pronation, and these are movements which seldom are carried to a maximum actively and they may be performed with uncertainty for this reason alone. This surprising result emphasizes the necessity of repeating a motion, the amplitude of which is in question, and of caution in drawing conclusions from a single series of measurements, especially in clinical cases in which movements may be accompanied by discomfort or other limiting conditions.

No characteristic differences were encountered in individuals who had suffered sprains of the wrist or fracture of the bones of the forearm, but it is not implied that these things always are without effect.

Since the average measurements on the two sides, for the whole group, agreed very well, it is unlikely that any special allowances must be made. The amount of average motion does not seem to be larger on the right than on the left, which is not what one might expect. The mean of the averages for the two sides could hence serve as a fairly reliable index of the amount of motion in normal wrists in the ages and occupations included.

The averages for the different age groups showed more agreement than I had anticipated. The youngest group, from eleven to fifteen, showed the greatest difference, for all the measurements were a little less than the general average, except abduction and extension in the position of pronation, which were greater on both sides (Table 3).

The sub-groups for the 16–20 year period showed an interesting difference, for all the measurements on the college group (33 in number) were greater than the general average, and greater than those of the high school group, except that abduction in pronation was less, on both sides, than in the high school group and the whole group. The average for the high school group (35 in number) was less than that for the entire group in all motions, except that abduction in pronation was a little larger on both sides.

The greatest differences in all the groups were observed in adduction and abduction in pronation. The largest measurements for these motions were obtained in the 11–15 year and the 16–20 year high school groups. The smallest measurements were obtained in the 16–20 year college group, although only a slight increase in amplitude over these was obtained in the older groups. I can offer no satisfactory explanation for this difference, for I know of no factor that would increase the range in all motions except abduction in pronation, and reduce the latter in the case of the college student.

*I have retained the terms adduction and abduction and flexion and extension in the tables because they are shorter.

TABLE 2

Individual Daily Variations

No.	Date	Supination				Pronation				Supination				Pronation			
		Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*		*Extension*		*Flexion*	
		R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
2	10-28-26	60	69	40	36	37	28	30	45	62	63	72	70	72	73	75	91
	10-30-26	58	67	36	40	37	31	32	44	62	61	70	70	70	73	81	92
	11-2-26	60	60	40	36	37	28	30	45	62	63	72	70	92	73	75	91
	11-4-26	67	61	30	35	34	37	34	39	65	57	67	72	70	84	85	85
	Variation	9	9	10	5	3	9	4	6	3	6	5	2	22	11	10	6
4	10-28-26	49	59	49	50	22	34	39	35	46	46	70	66	70	70	83	83
	10-30-26	31	46	31	32	30	32	25	24	34	50	66	66	72	75	75	75
	11-2-26	48	50	26	25	30	27	31	28	45	79	60	40	64	65	71	50
	11-4-26	38	49	30	26	38	27	32	25	50	54	51	75	65	68	91	74
	Variation	18	13	23	25	16	7	14	11	16	33	19	35	8	10	20	33
6	10-28-26	39	35	27	35	51	31	30	25	60	62	60	33	62	70	52	87
	10-30-26	69	49	33	36	48	43	40	35	52	60	66	63	60	63	67	69
	11-4-26	45	42	32	28	40	31	26	39	69	72	61	46	61	72	66	55
	11-9-26	57	54	45	33	58	55	36	34	72	89	61	73	72	80	86	86
	Variation	30	19	18	8	18	24	14	14	20	29	5	40	12	17	34	32
7	10-28-26	81	85	52	70	49	55	38	37	47	50	72	70	83	70	72	85
	11-4-26	50	84	34	41	71	48	41	35	60	56	80	88	70	83	83	82
	11-9-26	54	53	26	33	78	75	39	45	72	64	60	71	68	79	54	95
	11-11-26	81	83	38	42	55	55	43	44	61	63	70	74	64	74	94	88
	Variation	31	32	26	39	29	27	5	10	25	13	20	18	19	13	40	13
3	10-28-26	63	70	31	37	32	41	30	24	67	70	55	55	73	80	73	80
	11-2-26	34	50	20	18	39	37	34	20	70	60	50	75	65	60	80	70
	11-9-26	55	51	21	19	31	23	20	21	66	51	45	57	90	69	72	60
	*11-9-26	50	56	21	21	47	30	25	28	88	61	63	70	91	70	80	82
	11-11-26	60	59	22	15	41	43	31	30	72	73	67	74	65	92	80	73
	Variation	33	20	10	17	16	20	14	10	22	22	22	20	21	22	8	22
12	10-28-26	48	42	34	25	76	55	33	30	68	60	79	71	76	74	90	90
	11-9-26	62	71	26	30	44	53	30	31	72	69	69	73	75	72	94	87
	**11-9-26	80	65	28	30	45	40	22	26	71	67	80	71	81	70	100	96
	Variation	32	23	8	5	31	15	11	5	4	9	11	2	6	4	10	9

*Repeated after rapid exercise eight times in each plane.
**Repeated one hour later.

TABLE 3

AVERAGE AMOUNT OF MOTION IN THE DIFFERENT AGE GROUPS

Age Group	No. in Series	Supination				Pronation			
		Adduction		*Abduction*		*Adduction*		*Abduction*	
		R.	L.	R.	L.	R.	L.	R.	L.
Whole Group	112	62.5	60.9	27.0	27.8	33.0	31.5	38.4	39.4
11–15 inc.	17	60.4	57.5	17.9	20.9	22.7	24.3	42.2	43.6
16–20 inc.	68	63.8	62.3	27.6	27.8	34.6	32.8	38.1	44.5
16–20 High School	35	61.9	59.9	17.9	20.9	21.8	23.1	42.4	45.1
16–20 University	33	66.0	64.7	37.3	34.7	47.5	42.6	33.8	33.9
21–25 inc.	19	60.5	59.3	33.3	30.5	35.8	32.1	36.6	37.3
26 and over	8	59.5	60.9	31.0	34.6	36.6	36.6	36.5	33.5

Age Group	No. in Series	Supination				Pronation			
		Extension		*Flexion*		*Extension*		*Flexion*	
		R.	L.	R.	L.	R.	L.	R.	L.
Whole Group	112	64.0	64.7	69.4	67.7	68.4	73.5	80.0	81.1
11–15 inc.	17	61.1	61.5	66.9	63.2	66.4	73.4	75.0	75.4
16–20 inc.	68	65.2	65.4	70.4	68.6	67.5	73.4	81.0	82.0
16–20 High School	35	61.0	63.8	69.7	64.3	66.4	71.8	77.4	79.5
16–20 University	33	69.5	67.1	71.2	73.0	68.7	75.1	84.6	84.5
21–25 inc.	19	63.6	65.8	71.1	71.1	70.3	74.2	82.6	83.1
26 and over	8	62.0	62.1	66.7	62.1	75.6	74.0	76.8	83.1

TABLE 4

AMPLITUDE OF MOTIONS AT THE WRIST

		Supination		Pronation	
		Right	Left	Right	Left
Ulnar Flexion:	Average	62.5	60.9	33.0	31.5
	Maximum	88.0	85.0	76.0	66.0
	Minimum	36.0	35.0	9.0	12.0
Range of Difference		52.0	50.0	67.0	54.0
Radial Flexion:	Average	27.0	27.8	38.4	39.4
	Maximum	59.0	70.0	58.0	59.0
	Minimum	4.0	4.0	20.0	20.0
Range of Difference		55.0	66.0	38.0	39.0
Dorsiflexion:	Average	64.0	64.7	68.4	73.5
	Maximum	91.0	95.0	95.0	98.0
	Minimum	31.0	43.0	33.0	42.0
Range of Difference		60.0	52.0	62.0	56.0
Volar Flexion:	Average	69.4	67.7	80.2	81.1
	Maximum	101.0	116.0	102.0	106.0
	Minimum	40.0	31.0	52.0	57.0
Range of Difference		61.0	85.0	50.0	49.0

*Repeated after rapid exercise eight times in each plane.
**Repeated one hour later.

TABLE 5

EFFECT OF USE ON THE AMPLITUDE OF MOTION

Group	No. in Series	Supination				Pronation				Supination				Pronation			
		Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*		*Extension*		*Flexion*	
		R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
Averages:—																	
Whole group	112	62.5	60.0	27.0	27.8	33.0	31.5	38.4	39.4	64.0	64.7	69.4	67.7	68.4	73.5	80.0	81.1
Right handed	99	62.7	61.2	27.3	27.9	33.1	31.5	38.4	39.0	64.5	65.5	70.2	68.6	67.7	74.3	80.2	81.2
Left handed	3	64.3	56.3	21.3	25.6	35.0	33.0	35.6	41.3	67.0	58.0	64.6	66.3	64.0	62.3	85.3	89.6
Ambidextrous	13	60.8	58.8	24.7	25.1	32.4	30.8	38.5	42.2	61.2	58.2	64.2	61.9	66.5	67.8	78.1	81.3

TABLE 6

AVERAGE AMOUNT OF MOTION IN THE DIFFERENT TRAINING GROUPS

Group	No. in Series	Supination				Pronation				Supination				Pronation			
		Adduction		*Abduction*		*Adduction*		*Abduction*		*Extension*		*Flexion*		*Extension*		*Flexion*	
		R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
Whole group	112	62.5	60.9	27.0	27.8	33.0	31.5	38.4	39.4	64.0	64.7	69.4	67.7	68.4	73.5	80.0	81.1
Sports	8	60.2	55.9	25.8	22.1	30.8	26.1	35.2	36.4	66.3	68.1	68.5	72.5	68.1	73.8	78.7	78.4
Typing	2	60.0	57.5	36.0	25.5	44.5	41.0	32.0	32.0	73.0	70.0	75.5	75.0	76.5	79.0	76.5	71.5
Violin	2	67.5	62.5	44.5	36.0	40.0	39.0	54.0	42.5	68.0	70.5	75.0	84.0	74.5	78.5	80.0	88.5
Piano	13	61.8	62.6	24.1	30.0	27.8	26.8	40.6	41.0	61.2	65.1	72.3	71.8	70.4	72.8	81.9	83.2

The maximum and minimum for each motion were selected and the difference between them determined, but they were not constant. A minimum of 20 degrees and a maximum of 58 degrees were obtained for abduction in pronation, on the right side, with a difference of 38 degrees. The minimum was 33 degrees and the maximum 116 degrees, with a difference of 85 degrees, in flexion in supination (Table 4) on the left side. These represent the extremes in differences, and there was no constant or consistent difference between left and right for the different motions. As shown in this table, the amplitudes averaged for both sides, in supination and pronation respectively, are as follows: for adduction (ulnar flexion) 61.7 degrees and 32.2 degrees; for abduction (radial flexion) 27.4 degrees and 38.7 degrees; for extension (dorsiflexion) 64.3 degrees and 70.9 degrees; for flexion (volar flexion) 68.5 degrees and 80.6 degrees. The more constant measurements for the movements in pronation and the less constant for those in supination, may be due to more constant use and hence greater accuracy in the prone position, and to the more favorable position of the soft parts. The muscles can be used more efficiently because they are under greater tension, and hence can contract more effectively.

The small group of left-handed and ambidextrous individuals showed no characteristic difference in the range of the left wrist, due to a predominant use of it, nor did more equal use of both hands result in uniform motions (Table 5).

The training groups (Table 6) included only those who gave a history of long and persistent practice in a particular exercise, and only those who had studied and practiced constantly with the piano or violin for a period of four years or longer were considered. The two typists included had considerable training previous to two years of employment. Only those who were proficient in at least one sport were considered in the sports or athletic group, and they led a life in which the exercise of such sports as tennis, golf, hockey, cricket, and similar games, was a constant factor over a period of four or more years.

The results obtained in this small series of individuals would seem to indicate that long continued exercise and training affects the range of motion, and a uniformity in range of motion between the two wrists was noticed particularly in the sports group. This was also true of the group of pianists, but with slightly less regularity. A marked difference in the pianist group was noticed in the increase of abduction in pronation in both wrists. It was above average, but adduction in pronation was definitely less than average in this group. This may be due to the fact that this motion is not used to any extent in piano playing, while the former is. In the sports group, the difference between abduction and adduction in pronation was less than in the pianist group, which is consistent with my suggestion, for the equality in the training in both of these motions in the sports considered would tend to eliminate differences.

The small group of typists showed nothing outstanding. This is probably due to the system of training which teaches the predominant use of the

fingers with limited wrist motion. The observations on the two violinists would hardly be convincing, but the movement in the left wrist was less than that in the right in abduction and adduction, and greater in extension and flexion. This could be expected, for the left hand fingers the strings so that the finger and wrist muscles affecting flexion and extension, are constantly in use. The right wrist, on the other hand, is active in the bowing and hence showed a greater range in adduction and abduction, which are much concerned.

My measurements seem to indicate (1) that the active motions at the wrist are not accurately controlled and coordinated, and that any averages are hence only rough approximations; (2) that special but not ordinary use increases the amount of motion of one wrist more than the other; (3) that slight differences exist in the average amount of motion in the different age groups; and (4) that intensive exercise over a long period of time increases the accuracy and the range of the maximal motions.

I gratefully acknowledge my indebtedness to Dr. Meyer for suggesting the topic and supervising the investigation, and to my fellow students, friends, and young camp wards for willingly submitting themselves to the inconveniences of measurement.

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COMMENT

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Although the investigation of Miss Hewitt on women was done several years after that of Mr. Cobe, mainly on men and on some women, and without knowledge of the results obtained, they confirm each other in a very striking way. This implies not only that the measurements and calculations of both were made carefully, but that the groups were fairly homogeneous and essentially comparable.

A comparison of the averages obtained by Miss Hewitt and by Mr. Cobe does not reveal any consistent differences such as might be due to sex. In a number of instances the averages for the same motion are almost identical in the two sexes, and there is no pronounced difference in any motion. The greatest differences noted between the sexes were exceeded

not only by the fluctuations in individuals of the same sex, but also by those of the same movement in the same person.

The greatest daily fluctuation in a particular motion in different individuals was almost 400 per cent., and individual differences in fluctuations in all motions were almost as much. The fluctuations in the daily amplitude of motion not only were very considerable, but also irregular, so that it is difficult to generalize, but perhaps it may be said that the least accurately controlled motions were those of ulnar and radial flexion in supination; and the most accurately controlled was that of abduction in pronation, and next to that, those of extension and flexion in pronation.

The fact that the motions measured were made no more accurately with the right than with the left hand may seem surprising, but probably is due to the fact that most persons use the one hand about as much as the other, and that the motions concerned seldom need to be made with great accuracy or to a maximum extent.

SUBCUTANEOUS RUPTURE OF THE BICEPS FLEXOR CUBITI
Report of one Case

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A review of the literature shows that comparatively few cases of a subcutaneous rupture of the biceps flexor cubiti muscle have been reported, while most authors admit that there is no doubt there are many cases which are not reported.

A detailed description of the etiology, mechanism of the occurrence, symptoms, and treatment seems to be entirely unwarranted and would only be a duplication of the detailed and descriptive articles by Gilcreest[1], Ludington[2], Mason[3], Speed[4], Rocyn-Jones[5].

Briefly the conclusions from a review of the above authors reveal the following:

(1) Gilcreest states that the literature shows a report of eighty-one cases of subcutaneous rupture of the biceps, not including the personal report of six cases to Gilcreest by Henderson of the Mayo Clinic. A further review by the author, however, shows that Speed reported nine cases, Mason reported one case, and Rocyn-Jones reported three cases.

(2) These cases are frequently overlooked and diagnosed as a sprain or a simple hematoma.

(3) The site of the rupture may be at any one of four points,—namely, in the muscle substance, at the junction of the muscle and tendon, in the tendon, or at the origin or the insertion of the tendon to the bone.

(4) Gilcreest believes that the biceps and triceps of the arm are third in order of frequency in occurrence as regards muscular rupture, stating that about sixty-six per cent. are in the muscle substance. These muscles are only excelled in frequency of involvement by the Achilles tendon and the extensor quadriceps respectively.

(5) Sudden muscular violence and contracture, with or without a sudden external force, and certain motion of the forearm, as supination and flexion, also senility and excessive fatigue are the most common predisposing causes or etiological factors.

(6) The symptoms and the diagnoses are best brought out by the presence of an enlargement or a swelling which varies according to the severity of the muscle rupture. Pain and history of an injury and the finding of a definite gap between the muscle substance, in most cases, make possible a positive diagnosis.

Huerter's sign is also a helpful sign of biceps rupture,—that is, flexion

of the forearm in pronation when the biceps is tense is more forcible than when the arm is in supination and the biceps is relaxed.

(7) The treatment is immediate exposure of the ruptured muscle, preferably with the "hockey-stick" incision, and a complete suturing of the muscle and fascia with interrupted chromic catgut and a standard closure of the skin. Fixation of the arm, forearm and shoulder in a proper splint or dressing to prevent any motion of the elbow or shoulder joint and any strain on the biceps until healing has taken place, should always be done. The splinting is very important and, unless motion is closely watched, union in the muscle will not take place. The author has found that a posterior plaster splint extending from the middle of the back along the posterior region of the shoulder, arm, and elbow to the base of the fingers, with the elbow flexed to right angle, is very valuable.

The author's case is presented as follows:

A negro male, P. R., age thirty-eight, well developed, was admitted to the Orthopaedic Clinic of the Employees' Hospital of the Tennessee Coal, Iron and Railroad Company, Fairfield, Alabama, on December 2, 1927. Patient gave a history of an injury a few moments previous while working in an ore mine. Patient stated that while he was holding on to a drill handle (the position of the forearm being forcible flexion and supination), his foot slipped and an ore car ran over his right leg, suddenly pulling his arm and hand from his hold on the drill handle.

Examination on admission to the hospital showed a definite subcutaneous separation of the main belly of the right biceps flexor cubiti (Fig. 1). There was only slight abrasion on the skin; no other wound on the arm whatever was present. Patient had a laceration over right frontal region and a severe compound comminuted fracture of the middle third right tibia and fibula with 3.5 plus injury to the soft structures[6]. Ether anaesthetic was given immediately, a "hockey-stick" incision was made through skin and fascia of the right arm with excellent exposure of the ruptured muscle. Inspection revealed a complete division of both bellies of the biceps through the middle. The

FIG. 1

Showing rupture of the right biceps flexor cubiti, comparing right arm with left arm.

edges were so smooth that they gave the appearance of having been cut by some sharp instrument rather than being torn. Excellent approximation of the muscles, fascia, and the skin was obtained and a posterior plaster fixation splint as described was applied. Laceration of the scalp was sutured. All supports on the right leg were removed and a Steinmann pin was applied through the os calcis and traction used, after which proper attention was given to the compound wound of the leg[6]. Patient had an uneventful recovery and excellent results of the arm. He still has some disability in right leg, but will soon be able to discard crutches entirely and should be able to return to his former occupation.

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TREATMENT OF UNCORRECTED DEFORMITY IN FRACTURES OF THE SHAFT OF THE FEMUR

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The most experienced surgeons see fractures of the femur which, in spite of skillfully employed conservative methods, cannot be satisfactorily reduced. Frequently, however, the failure of early reduction may be due to poor methods of treatment or to overoptimism that union will occur and function be not impaired by poorly reduced fractures.

The combination treatment of direct skeletal traction, Hodgens splint, and Balkan frame, is as satisfactory in the treatment of uncorrected deformity of old partially united unreduced fractures requiring open operation as it is in the acute fracture of the shaft of the femur.

The history of unreduced fractures of the femur is frequently as follows:—The patient had a fracture of the femur which has been treated for a period of ten days to five weeks. There remains faulty position which will result in impaired function if unreduced. The case is referred for treatment. What is to be the procedure to correct the existing malposition?

After a fractured femur has been unreduced for a period of eight days, complete reduction cannot be obtained by closed methods. Therefore some type of open reduction must be done. The application of bone plates such as the Lane type, or the Smith bone clamp, or wiring of the fragments, or any procedure in which foreign material is introduced at the site of fracture to hold the fragments in apposition, requires more or less extensive cleaning of the fractured ends of muscle and newly formed callus.

An operation which produces the least trauma, yet which allows satisfactory reduction of fragments, should be the operation of choice. The following procedure offers an efficient and satisfactory method of reduction. Any fracture of the shaft of the femur which could have been reduced by direct skeletal traction within the first week can be reduced by the same traction plus a minimum trauma open operation described below:

Under general anaesthesia a Steinmann nail is inserted through the distal end of the femur just proximal to the condyles, before breaking up the callus at the site of fracture. An incision three inches in length is usually ample over the site of fracture. The fractured ends are exposed by careful dissection. Sharp spicules of bone may be removed or, if fragments interfere with reduction, they may be removed. However, no more

trauma to the newly formed callus is done than is absolutely necessary to obtain satisfactory reduction. While an assistant is making traction on the Steinmann nail, a pry bar is inserted between the fractured ends. In transverse or slightly oblique fractures the ends may be pried apart and approximated without difficulty. If there is an oblique fracture and no great leverage can be obtained by the pry bar, while the assistant makes traction on the inserted Steinmann nail, the newly formed callus may be broken through and the fragments manipulated, until no doubt exists that traction will satisfactorily accomplish the reduction. Under direct vision the fragments are pulled into place, and it is demonstrated that continued traction on the Steinmann nail or on the tongs will hold the fractured ends in alignment. Should interposed muscle tend to prevent apposition of fragments, the trouble can at once be remedied. If one is uncertain as to the number of pounds necessary to maintain the fragments in apposition, a small metal spring scales may be attached to the tongs and the amount of pull necessary determined at that time. The incision is then closed.

Very frequently the knee and ankle joints have already become somewhat stiffened from immobilization or traction. Physiotherapy should be started as early as possible to prevent further damage. New bone formation seems to be stimulated, rather than impaired, by the breaking of the callus. Passive motion and massage can usually be started within a period of ten days following operation, and the knee and ankle should be freely movable and normal in appearance by the time the fracture is united.

The importance of frequent x-ray pictures in two planes during the period of skeletal traction cannot be overestimated. It is very easy to produce separation by overextension and this can only be prevented by frequent examinations and the use of the x-ray. The production of overextension and lengthening is to be avoided, as this impairs function as much as shortening.

Direct skeletal traction can usually be removed after a period of fourteen days, although a longer period may be required. Active motion is usually permitted after one month, although the x-ray picture and the stability of the fracture should be the deciding factor in starting active motion.

Weight-bearing should not be permitted for at least eight weeks. The period at which weight-bearing is allowed is entirely dependent upon the firmness of the union and the nature of the fracture.

The following cases illustrate the type of case for which this treatment is satisfactory:—

Case 6025. A seaman, aged thirty-nine, fell, striking on his right leg and producing an oblique fracture of the right femur in its distal third. He was taken to a hospital where treatment was rendered. Thirty-one days after the accident he came under our care. At the time of admission to the hospital he showed two inches of shortening of the femur, due to overriding, and the knee and ankle were stiffened and painful. On the thirty-fifth day following the fracture he was given a general anaesthetic. A Steinmann nail was inserted just above the condyles, an incision was made three inches in

length, a sharp spicule which was about to penetrate the knee joint was removed, and the shortening of two inches was reduced by combined traction on the Steinmann nail and the use of the pry-bar. An x-ray taken the day following showed satisfactory reduction. Eight days later another x-ray showed lengthening of a quarter inch beyond normal. The weights were at once reduced, and an x-ray on the fourteenth day showed still slight lengthening of about one-eighth inch. Passive motion was started on the tenth day and active motion on the thirtieth day. The knee and ankle rapidly regained their normal motion.

Case 4535. A man, aged thirty-eight, was struck by an automobile, fracturing the left femur at the junction of the middle and lower thirds. He was taken to a Baltimore hospital where a plaster cast was applied. At the time he came under our care there was posterior displacement and angulation of the distal fragment with one-half inch overlapping. Thirty-six days after the fracture the patient was given a general anaesthetic, an incision was made over the site of fracture, and with a pry-bar the fractured ends were brought into apposition and alignment. Skeletal traction by means of the Steinmann nail was continued for a period of eighteen days. The knee and ankle joint which were very stiff and painful regained their normal motion very slowly. The end result was alignment without shortening.

FIG. 1

Case 1. Anterior posterior view, thirty-six days after occurrence of fracture. Two inches of shortening. Sharp spicule of proximal fragment about to penetrate into joint cavity.

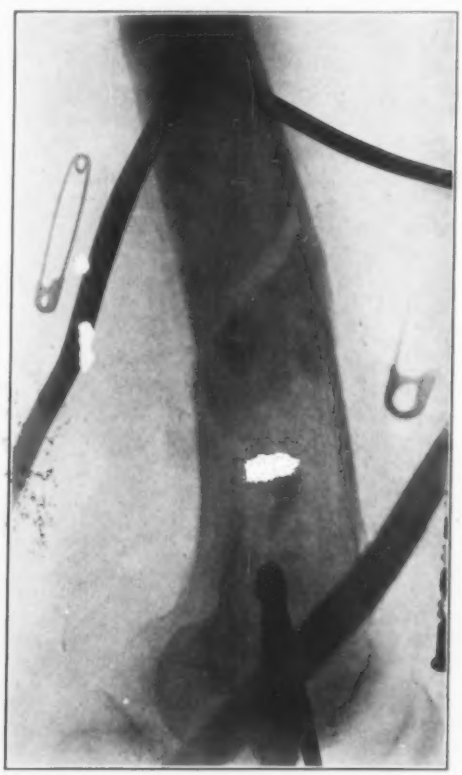

FIG. 2

Case 1. One week after reduction of fracture. Lengthening due to too much weight applied to Steinmann nail. Alignment satisfactory. Weight reduced, with resulting satisfactory position as shown by another x-ray one week later.

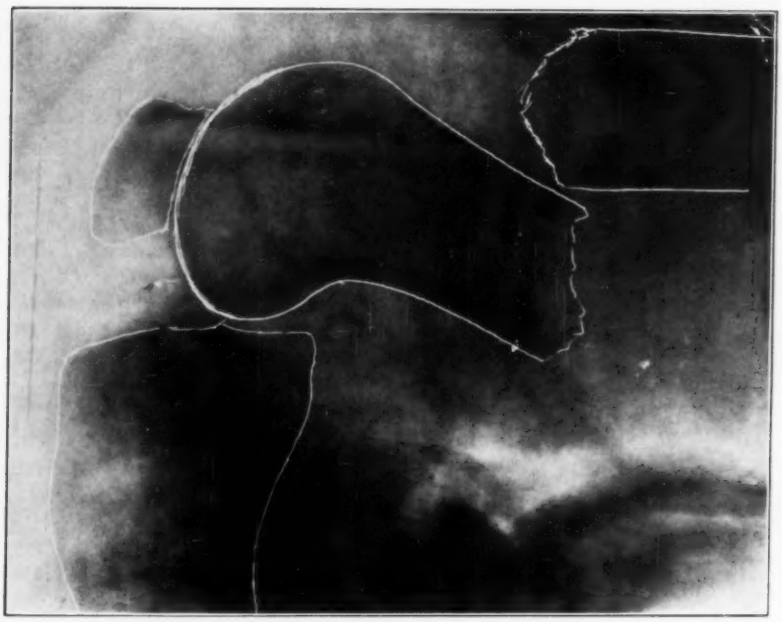

FIG. 3

Case 2. Fracture of femur in plaster cast unreduced thirty-five days after occurrence. Posterior displacement, angulation and shortening present.

FIG. 4

Case 2. Lateral view, at end of six weeks after reduction. Abundant callus formation, especially marked on anterior aspect.

SUMMARY

Efficient first aid, early reduction of the fracture, elevation of the fractured part, early mobilization of the extremity, early massage, and active motion will reduce the damage and prevent disability in fractures of the femur.

Any fracture that could have been reduced within the first week by direct skeletal traction can be reduced by this same traction, plus a minimum trauma open operation. In treatment of unreduced fractures, early reduction by tongs or nail combined with minimum trauma open operation is the method of choice.

By this method the newly formed callus is traumatized relatively little, and the danger of infection, delayed union, and non-union is minimized.

The combination treatment of direct skeletal traction, Hodgens splint, and Balkan frame, is as satisfactory in the treatment of old partially united unreduced fractures requiring open operation as it is in the acute fracture, and is the procedure of choice.

PROGNOSTIC SIGNS IN THE X-RAYS OF TUBERCULOUS SPINES IN CHILDREN*

BY RALPH K. GHORMLEY, M.D., AND JOHN I. BRADLEY, M.D., BOSTON

The study of a single x-ray picture of a tuberculous spine is of interest from a diagnostic standpoint, but from a prognostic standpoint is of much less value than a series of x-rays on the same patient. The material for this study consists of seventy such series taken at the New England Peabody Home for Crippled Children. These pictures were taken at four-month intervals over a period of from two to five years or more. The cases have for the most part been treated by conservative methods,—recumbency during the early stages of disease, combined with heliotherapy, fresh air, and the usual modern requisites in good general care of tuberculous patients. These estimates therefore would probably vary somewhat in a series of operated cases.

The study may be divided in so far as prognostic signs are concerned into—

1. The changes observed in the tuberculous lesion itself.
2. The changes observed in the tuberculous abscess.

The changes in the lesion may be summarized as follows—

(a) Changes in calcification in the lesion (either increase or decrease).

(b) Changes in detail in the lesion.

(c) Progressive destruction.

(d) X-ray evidence of fusion of vertebral bodies or "bony block".

By *changes in the calcification* we mean an increase or decrease in the lime salt deposit about the lesion. This may appear as a dense white shadow either spotty or compact. This must not be confused with actual reestablishment or reappearance of the bony trabeculae. This we have included under the subheading of *changes in detail in the lesion.* The changes are very different in their character and from the observations here are of widely separated clinical significance. The former change represents a calcification which has taken place in the broken down material about the lesion and in the abscess and, while it may represent an attempt at repair, from a study of the contents of a calcified abscess removed at autopsy one can see that such calcified material offers poor support for the vertebral column. From the accompanying table it is obvious that it is of little value as a guide to actual healing by bony fusion.

On the other hand, the reestablishment of trabeculae which may be

*Read at the Meeting of the American Orthopaedic Association at Washington, May 2, 1928.

observed as *clearing* or *improvement in detail* in the lesion is of value as a sign of repair in the damaged bone and, when observed in a series of plates to be definitely increasing, may be taken as a sign of improvement.

The *increasing destruction* needs no explanation. A word as to its significance. Most of the acute cases taken under treatment will show some degree of progressive destruction of the vertebrae involved over a period of a few months to a year. Then, with the improvement in the patient's general condition and the establishment of a resistance, improvement is noted.

The establishment of bony block may be questioned by some, but there is often x-ray evidence that such fusion between partially destroyed vertebrae may take place, and from the behaviour of these cases clinically it would seem that they are the most favorable type so far as a permanent arrest of the disease is concerned.

The changes in the abscess may be divided into—

(a) Increase or decrease in size of the abscess, and

(b) Calcification not shown as increasing or decreasing.

These changes are summarized in the accompanying table.

The importance of the abscess accompanying tuberculous spines cannot be overemphasized. Its presence should be diagnosed if possible, and with careful x-rays it should be noted where present in a large percentage of cases. It may be fairly transitory at times, disappearing within a few months, and so only seen where serial x-rays are available. Nichols[1] states, "In a considerable proportion of cases of tubercular disease of the spine no abscess is recognized during life, but in cases seen at autopsy an abscess is almost invariably found, although it may be of small size". Vulpius[2], quoting various authors, places the percentage of cases of Pott's disease showing abscess all the way from twelve and one-half to fifty-nine per cent. Rauenbusch[3] quotes the percentages from various authors from ninety-nine to thirty-three and one-third per cent. From these percentages, some of which are based on autopsy material, but for the most part taken from clinical observation, it must follow that the diagnosis of the presence of an abscess is often overlooked.

From the standpoint of this study, the behavior of the abscess is quite as important as the behavior of the lesion itself. This is particularly true of abscesses and lesions of the thoracic vertebrae.

As shown in the accompanying table *decrease in the size of the abscess* is of good clinical significance. The high percentage of cases showing *no calcification in the abscess* is misleading perhaps, but represents a group in which the abscess apparently was absorbed early without any calcification taking place.

Increase in the size of the abscess may be taken as of poor prognostic significance. *Increase in calcification in the abscess* is of relatively little significance, though it means a tendency toward improvement.

TABLE 1.

Percentages Represent Clinical Improvement in Each Group

1. Increased detail in lesion	94.4%
2. No calcification in abscess	90.9%
3. Decrease in size of abscess	90.0%
4. Bony block	88.8%
5. No change in size of abscess	70.6%
6. Progressive destruction	68.2%
7. Increasing calcification in lesion	68.1%
8. Increasing calcification in abscess	66.0%
9. No change or decreased calcification in lesion	65.3%
10. No change or less detail in lesion	47.6%
11. Increase in size of abscess	18.1%

A group of abscesses not seen in the x-rays are those which have ruptured and become draining sinuses. These are usually, of course, of poor clinical significance. The authors have never seen an abscess draining with secondary infection show any appreciable amount of calcification by x-ray.

We have already referred to the importance of the behavior of the abscess, particularly those associated with lesions of the thoracic spine. It is to this particular lesion that this study has brought us. In eighteen of these cases of thoracic Pott's disease, there may be seen, besides the tuberculous lesion proper, a peculiar erosion of the anterior portion of the vertebral body. This is demonstrated usually in the lateral x-ray only (Fig. 1). It is, as a rule, smooth, cup-shaped, with the intervertebral discs remaining intact and often a small margin of bone along the disc to its extreme edge. The appearance is so like the erosion of an aortic aneurysm on the vertebral body that one cannot but feel that a mechanical pulsating force must play a part in some of these cases.

The number of vertebrae involved in these lesions, besides those in the tuberculous lesion proper, varies from one to six. If we study the anterior-posterior x-rays in these cases, we will see shadows representing an abscess either fusiform (Fig. 2), pyramidal, or globular in shape. The extent of the abscess usually corresponds with the extent of the erosion, or may extend somewhat farther. They are practically always confined within the thoracic cavity,—that is, they are limited below by the diaphragm and above by the muscles and fasciae at the apex of the thorax.

The eroded area in all cases is included within the limits of the abscess, and in many cases is very smooth in outline. As the abscess progresses away from its lesion, the amount of erosion diminishes in each vertebra. There are, on the other hand, some of these cases that show a more irregular type of erosion of the vertebrae suggesting an inflammatory type of lesion.

While it would be difficult, without pathological section of these spines, to prove the presence of a purely mechanical influence in their spread, the evidence seems to point toward the fact that at least this is an important

factor in the spread and development of some of these abscesses.

That such a dissecting abscess has been recognized long since is obvious in a review of the literature. Menard[4] describes such an abscess and many variations of it. He, of course, shows no x-rays. His cases show the widest range of variations in distribution and type of destruction. Then, too, Wullstein[5] describes such a lesion as we have observed here, calling it a "peripheral form" of tuberculosis of the spine. His explanation of the origin of the condition is that it is due to a simultaneous seeding of several vertebrae in their "anterior vascular zones". From these areas a confluent abscess forms and we have our picture. This explanation does not seem to cover the ground sufficiently. It does not explain the variation in size of the erosion, always greater nearest the true tuberculous lesion and diminishing as the more distant vertebrae are reached. Wullstein mentions the resemblance to aneurysmal erosion. Another who has described the lesion from the clinical viewpoint is Neumann[6], who described a triangular area of paravertebral dullness due to such abscesses.

FIG. 1

Lateral view showing anterior erosion of four bodies above the central lesion and one below. Note the persistence of the intervertebral discs and the thin layer of bone attached to them in some places.

From the x-ray standpoint we have several observations. Kankeleit[7] has described the normal soft tissue shadows seen along the thoracic spine. There is a normal stripe which he believes due to lung and pleura, besides the shadows for the aorta and heart. Zander[8] mentions a case showing a triangular abscess shadow with an extreme Pott's disease. Roederer and Albert-Weil[9] describe two types of abscess, fusiform and ovoid, but do not attach particular clinical significance to either of the types. Rach[10] gives the physical signs of such an abscess and points out that x-rays in the ventrodorsal position are more clear than those taken in the opposite direction. Kloiber[11] also described these abscesses and Sgalitzer[12] outlines in considerable detail his conception of these abscesses as to their formation, differential diagnosis, and treatment. He feels that dorsal Pott's is, in two-thirds

FIG. 2

Fusiform type of abscess extending up and down the thoracic spine. These rarely pass below the level of the pillars of the diaphragm.

of the cases, accompanied by an abscess demonstrable by x-ray, and that the abscess may be demonstrated before the lesion in the vertebra. Dubrow[13] reports three cases of tuberculosis of the spine with mediastinal abscess showing in the x-ray. Steindler[14] states that fifteen per cent. of all cases of dorsal Pott's disease show abscess formation, and of his series over half showed paraplegia.

Willis[15] described the autopsy findings in four cases of dorsal Pott's disease, showing that the lesion may be more widespread than suspected, and that multiple foci often exist where not suspected. Also, there may be extensive lesions with only superficial erosions of bone.

Massart and Ducroquet[18] state that in dorsal Pott's disease the abscess remains "hidden" but may be detected by x-ray, and its presence is absolute evidence of Pott's disease.

From this brief and probably very incomplete review of the literature one can see that this particular phase of tuberculosis has not passed by unnoticed, and yet it has impressed the authors as being very little talked of and of tremendous importance in consideration of any case of thoracic spinal tuberculosis. Nichols[1] describes this lesion as follows,—"The process generally extends forward to the deep layer of the prevertebral ligaments which act as the periosteum of the vertebrae, and extends upward and downward from the original focus. As the disease reaches the level of each vertebra it attacks the body of that vertebra and forms a new area of tubercular softening. Often several vertebrae show such areas. The vertebra primarily attacked shows the most extensive areas of softening, while those on either side show gradually smaller areas."

This explanation satisfies the purely inflammatory type of extension; but why should the intervertebral discs remain intact where the lesion is a progressive tuberculous process? For this reason the authors contend that in some of these cases the mechanical pressure lifting up the periosteum, combined perhaps with the pulse transmitted through the abscess sac from the aorta, gives an aneurysm-like action and produces a more or less pure mechanical erosion. Such an explanation would satisfy the persistence of the intervertebral discs in these lesions.

That there are two types of lesion is further borne out by a study of pathological specimens in the Warren Museum where we see the inflamma-

FIG. 3

Specimen from Warren Museum showing extensive destruction of the discs and partial destruction of the vertebral bodies. This may represent the inflammatory type.

FIG. 4

Specimen from Warren Museum showing destruction of anterior portion of vertebral body with dissection of the anterior ligament and persistence of the discs.

tory type with extensive destruction of bodies and discs (Fig. 3), and the mechanical type (Fig. 4) with extensive destruction of bodies without destruction of discs.

Furthermore we have mentioned the three types of abscess generally seen,—fusiform, pyramidal, and globular (Fig. 5). It is of some significance that in the latter type we rarely see the anterior erosion. This we believe due to the fact that the globular abscess represents one that has broken down the resistant wall of the anterior longitudinal ligament and has failed to dissect this ligament and the periosteum from the neighboring vertebrae.

The importance of the type of extension is not so great as the fact that these thoracic abscesses do extend from the primary bony lesion, dissecting the adjacent vertebrae free of their periosteum and leaving them lying more or less surrounded by the tuberculous abscess. If they are not at once destroyed, their ultimate fate must be at least partial destruction; for with the abscess persisting, their nutrition must suffer and in the end they must converge with the other destroyed bodies into a larger kyphos.

When one studies statistics he finds almost invariably a more extensive disease process in thoracic Pott's disease than in any other region. That this is directly due to the above condition seems plausible without much more convincing argument. The statistics in this series are as follows:—

TABLE 2.

	No. Cases	*Av. No. Vertebrae*
Cervical spine	2	2.5
Thoracic spine	40	5.95
Thoracic-lumbar spine	10	5.1
Lumbar spine	13	2.14
Double lesions	5	5.6

These do not vary greatly from the statistics quoted in the literature.

What is to be done to relieve this condition? It would seem wise, at first thought, to advocate drainage of these abscesses as soon as one can determine their presence and thus prevent, in all probability, the extensive dissection of the spinal column. Menard described the operation of costotransversectomy. This operation has been advocated from time to time without its adoption as a routine procedure. It is difficult to estimate the value of such a procedure when one has had no experience with it. A recent contributor[16] reviews the methods at hand for evacuating these abscesses and describes the method in use at the Istituto Rizzoli. He considers that Menard's procedure results in a permanent fistula. Calvé's method of drainage through the canal by a cannula is applicable usually to paraplegias. The method described by Valtancoli of drainage with a trochar passed between the ribs and along the vertebral body is more encouraging according to the author. Steindler[15] advocates costotransversectomy. Calvé's[17] method, as has been said, is applicable in cases of paraplegia but not designed to drain paravertebral abscesses. Sgalitzer[12] advocates drainage through a trochar and injection of ten per cent. iodin.

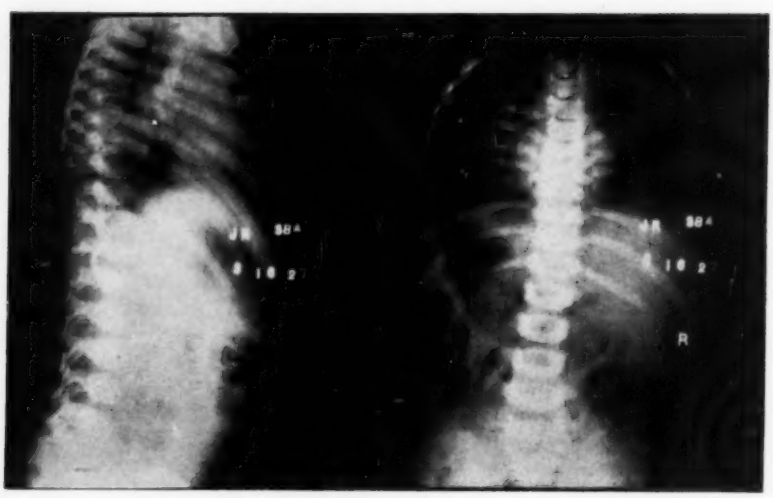

FIG. 5

X-rays showing "globular" type of abscess. This case does not show anterior erosion of the vertebrae.

He also warns against the costotransversectomy because of the danger of a permanent sinus resulting. Rach[10] advocates drainage through a needle or trochar. Zander[8] advocates a procedure similar to Menard's costotransversectomy without, however, giving any end-result figures.

CONCLUSIONS

1. Calcification in a lesion does not necessarily mean satisfactory healing.

2. Clearing or reestablishment of bony detail is a much better indication of healing.

3. Bony fusion or bony block is a favorable sign.

4. Decrease in the size of an abscess is a favorable sign, while increase in the size of an abscess is decidedly an unfavorable sign.

5. Paravertebral abscesses accompanying dorsal Pott's disease are dangerous in that they cause a much wider destruction than the original lesion. A mechanical pulsating force must play a part in their production.

6. It is suggested that early eradication of such abscesses might be attempted, but the danger of establishing a permanent sinus is serious.

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DISCUSSION

Dr. John L. Porter, Chicago: We welcome any paper which will help to elucidate a very baffling and unsatisfactory subject. One of the more recent attempts has been to make a prognosis as to tuberculosis of spines from what is shown in the x-ray films. It is thirty years next September since I purchased my first x-ray tube and since that time there have been few working days that I have not been called on to interpret films of bones and joints. Every day I have become more and more impressed not only with the difficulty of making prognoses, but with the difficulty of making *diagnoses*, of tuberculous bones on the x-ray findings alone. To try to interpret an x-ray picture in terms of prognosis is even more difficult than that of diagnosis. It is not difficult to understand why, when we stop to think that even the expert radiologists will differ in the interpretation of a given picture. Again, the picture of a tuberculous spine may look entirely different today from what it does the day after tomorrow. The detail of the bone brought out by a tube today and a picture next week with a different tube will show entirely different outlines.

Another thing is the difficulty of identifying abscesses. There is no doubt that many cases develop abscesses of the dorsal spine which are not identified. The picture today will be of such character that the abscess is quite indistinguishable, while one taken next month may bring out the abscess. You will say, "He is developing an abscess; see how it has increased since the last picture was taken". It was probably there all the time. The difference is in the pictures.

Another thing that Dr. Ghormley has not dwelt upon is the presence of sequestra. I have had good radiologists tell me that a picture showed definite improvement because it happened to show distinct bone formation, when actually the picture showed a bone sequestrum which had become more evident since the last picture was taken. When you dwell on all these things in the interpretation of an x-ray picture, there is no difficulty in deciding why it is such a delicate problem.

Dr. Ghormley has contributed one thought which is new to me, that is, that the apparent erosion above and below the lesion may be due to the pressure of an abscess, instead of an extension upward and downward from the focus of new areas of infection. When we look at the x-ray of a spine of a patient who for years has had tuberculosis and we see the vertebrae above and below becoming excavated, we have been in the habit of saying, "We are dealing with an extension of the disease". Whereas it is quite probable that the presence of an abscess burrowing under the anterior ligaments of the spine has made enough pressure to produce absorption of the bone. There is just one thing that is going to help us to clear up this subject, and that is the correlation of the postmortem findings with the x-ray. Every patient who dies of tuberculosis of the spine should go to the postmortem table and the x-ray pictures should be there. When we have held our postmortem and we find a sequestrum of bone or an abscess producing absorption, we have found something worth while in helping us to determine the value of the x-ray in prognosis.

TREATMENT OF VERTEBRAL TUBERCULOSIS BY THE SPINE FUSION OPERATION

A Report of Two Hundred and Eighty-six Cases

A Second Series*

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AND

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In June 1918 an end-result study of the first 210 cases of tuberculosis of the spine treated by the fusion operation was presented to the Orthopaedic Section of the American Medical Association. These were the cases operated upon during the years 1911 to 1914 inclusive, and each one was reported[1].

In continuation of that study, the results and some of the pertinent facts concerning the patients upon whom the fusion operation was performed, also at the New York Orthopaedic Dispensary and Hospital, from 1915 to 1920 inclusive are here presented. The series includes all of the patients with tuberculosis of the spine who were treated by fusion during that period. Ten of the first series who were not cured are included in the present group because they were subsequently operated upon again. Many of the other 210 have been examined from time to time since that report was made and no reason has been found to modify the conclusions which were made at that time.

The fact is constantly borne in mind in the treatment of these cases that tuberculosis of the spine is simply a local manifestation of a general disease, and everything possible is done to improve the general condition of the patients and to increase their resistance. The operation eliminates motion of the diseased joints and thus removes quickly its traumatizing influence upon the progress of the disease. The patients in this series were operated upon without selection, and, naturally, many were in an advanced stage of the disease and in poor physical condition before operation. The majority came from the poorer districts of the city and returned to the same conditions afterwards.

The report has been purposely delayed in order that a long time might elapse between the operation and the estimate of the result. This period varies from seven to thirteen years. In all, 286 patients were operated upon by seven members of the staff; 159 were males, and 127 females. The result was doubtful or unknown in thirty cases which were followed for an average of only two years, and therefore have been excluded. One

*Read before the American Orthopaedic Association at Washington, May 3, 1928.

hundred and eighty-one, or seventy and seven-tenths per cent. of the remainder, were cured. Eight patients, or three and one-tenth per cent., were not cured; and sixty-seven, or twenty-six and two-tenths per cent., died. In the last group were included, however, ten patients who died from some other cause than tuberculosis of the spine and in whom the latter was cured. If these cases are included, the cures become seventy-four and six-tenths per cent.

TABLE 1

Total number of cases		286
Total males	159—59%	
Total females	127—41%	
Unknown or doubtful cases		30
Total about whom end results are known		256
Cured cases	181—70.7%	
Not cured	8— 3.1%	
Cause: Paraplegia	2	
Sinuses	3	
Short fusion	3	
Deaths	67—26.2%	

It is difficult to state accurately the age of the patients at the time of the onset of disease because of the lack of definite knowledge about this on the part of the patients or their parents. Having this in mind, it appears that 235 cases were under sixteen years of age, and of these the great majority were under six years. There were only thirty-four cases in the age period from sixteen to thirty years, and seventeen in the period of thirty to fifty years. The mortality among those in whom the onset was under twenty-six years was twenty and six-tenths per cent.; among those between twenty-six and fifty, fifty-four per cent.

TABLE 2

AGE OF PATIENTS AT ONSET OF DISEASE

Age	*Cases*
Up to 5 years	174
6 to 10 years	42
11 to 15 years	19
16 to 20 years	8
21 to 30 years	26
31 to 40 years	14
41 to 50 years	3

It will be seen from the following table that by far the greater number of patients were operated upon at the age of from one to ten years and that the number decreases with each succeeding decade. It is true also that the mortality was highest among those who were operated upon in the period from thirty to fifty years of age.

TABLE 3

AGE OF PATIENTS AT TIME OF OPERATION

Age	*Cases*
Up to 5 years	111
6 to 10 years	71
11 to 15 years	31
16 to 20 years	23
21 to 30 years	29
31 to 40 years	16
41 to 50 years	5

The duration of the disease before operation cannot be determined with any great degree of accuracy for the same reason that the age of onset cannot, but according to the histories of the patients it was as follows:

TABLE 4

DURATION OF DISEASE BEFORE OPERATION

Number of years duration	*Number of cases*
Up to 3 years	199
3 to 5 years	51
6 to 10 years	15
11 to 15 years	17
16 to 20 years	3
Over 25 years	1

The average duration of disease at the time of operation was 3.7 years.

The average length of treatment after operation of those patients who were transferred to the country branch of the hospital was one year and seven months. At the period when this series of patients was being cared for, no provision was made for adults at the country hospital. It is estimated that among the adults the treatment after operation was about one year, this period being taken as the time during which they wore a brace and did not return to work. Many of the patients were treated elsewhere previous to their admission to the Orthopaedic Hospital. The methods of treatment included all of those of the conservative type now in vogue: among them, plaster jackets, various sorts of frames, and long periods of bed rest, etc. Nine patients had had bone-graft operations but still had active tuberculosis of the spine. It was found that in four of these cases the graft had absorbed; that in two the fusion was incomplete; and that in three the graft was united by fibrous union only. Six of these patients were cured after the fusion operation, the result was doubtful in two, and one died of pulmonary tuberculosis.

It will be seen from the following table that the largest number of cases occurred in the dorsal region, the next largest in the dorsolumbar and lumbar, and the smallest number in the cervical and lumbosacral regions. It is interesting also to find that a higher percentage of cures resulted in the cervical and lumbosacral areas. All of the cervical and cervicodorsal cases were found in young individuals, and the same was true in a somewhat lesser degree of the lumbosacral cases.

TABLE 5

AREA OF DISEASED VERTEBRAE

Area of disease	*Total cases*	*Total cured*	*Per cent. cured*	*Age of patients at onset of disease*			
				1–10 years	*11–20 years*	*21–30 years*	*Over 30 years*
Cervical and cervicodorsal	11	10	91%	91%	9%	0	0
Dorsal	149	93	62%	78%	9%	4%	9%
Dorsolumbar and lumbar	116	68	59%	70%	9%	14%	7%
Lumbosacral	10	8	80%	78%	11%	11%	0

More than one focus of disease in the spine was found in eleven cases, three and eight-tenths per cent. of the total. The areas are shown in the following table. In all but one case both areas were operated upon. Four of the cases were cured, the result was doubtful in three, and four patients died. The percentage of deaths here was thirty-six, or over ten per cent. higher than that of the entire series.

TABLE 6

AREAS OF DISEASE WHERE MORE THAN ONE FOCUS WAS PRESENT

Dorsal and lumbar	5 cases
Dorsal, two areas	4 cases
Dorsolumbar and lumbosacral	1 case
Cervical and lumbar	1 case
Deaths—Total	4
Cause: Meningitis	3
Unknown	1

Involvement of spinous processes and laminae, as well as of the bodies of the vertebrae, was found in six cases, or two per cent. In one case the disease was confined to the posterior arch. One case was in the cervicodorsal region, three in the dorsal and three in the lumbar. Two of these patients were cured, three died, the result was doubtful in one, and one was not cured.

Natural fusion of the laminae, articulations of the neural arches, and sometimes of the spinous processes as well, were found at operation in fifty-four cases, or nineteen per cent. The areas in which this was found were:

TABLE 7

AREAS IN WHICH NATURAL FUSION WAS FOUND AT TIME OF OPERATION

Area	*Number of cases*	*Per cent. of total number with disease in this area*
Cervical and cervicodorsal	3	30%
Dorsal	33	24.8%
Dorsolumbar	9	16⅔%
Lumbar and lumbosacral	9	12½%

The greatest number of vertebrae found to be fused in any case was eight. This occurred in the dorsal region of a boy eighteen years old who had had the disease for sixteen years. The youngest patients in whom natural fusion was found were one of two and one of two and one-half years of age, and the oldest was twenty-nine. The average duration of the disease before operation in these cases was seven years, and the average age at operation was eleven and five-tenths years. In all of these cases the extent of the natural fusion was inadequate to protect the diseased area and it was extended at operation. Often it was present on only one side, and sometimes was not continuous. Only thirteen per cent. of those with some natural fusion of posterior elements in the diseased area died. This is thirteen per cent. lower than that of the entire series. The extent of fusion is shown in the following table:

TABLE 8

NUMBER OF VERTEBRAE FOUND FUSED AT TIME OF OPERATION

Number of vertebrae	*Number of cases*
2	25
3	15
4	6
5	2
6	3
7	2
8	2

One case had two foci with natural fusion in both areas.

Palpable psoas abscesses were found in sixty cases at the time of operation. The focus of disease was in the dorsolumbar region in nineteen cases, lumbar in thirty-four cases, and lumbosacral in five cases. In twenty-six cases one or more sinuses communicated with the abscess, and in thirty-four cases the abscess was closed. The seriousness of a sinus as a complication is indicated by the fact that of those cases with sinuses only eight were cured and eleven died, whereas of those cases with closed abscesses twenty-three were cured and nine died.

Evidence of pressure on the spinal cord was present in forty-seven cases, of which twenty-three were classed as definite paraplegia and twenty-four as slight spasticity. The results in the first group were:

TABLE 9

CORD PRESSURE, RESULTING IN PARAPLEGIA

Total cases	23
Cured, paraplegia	5
Great improvement	3
Slight improvement	1
Not cured, paraplegia	7
Died	7
Areas of disease:	
Cervicodorsal	1
Upper-dorsal	2
Mid-dorsal	11
Lower-dorsal	8
Dorsolumbar	1

One case of paraplegia occurred in a patient with tuberculosis of the dorsolumbar region, and one in the cervicodorsal. The remainder all occurred in dorsal cases. Five of the paraplegic cases had laminectomies and two of these were cured of the paralysis.

The cases with slight cord pressure, manifested by exaggerated reflexes, resulted in eighteen cures, three doubtful results, and three deaths.

Six laminectomies were performed. Two patients recovered completely from the paraplegia and were cured of their disease. One of these patients, who was operated on at the age of four and one-half years, had had the paralysis for six months and was incontinent. A combined laminectomy and spine fusion was done. She was able to walk two years later, regained control of her sphincters at the end of eight years, and still was completely cured at the end of thirteen years. The other patient

cured was sixteen years old at operation, had had tuberculosis of the spine for fourteen years and paraplegia for eight months. A spine fusion had been done previously. He was able to walk six months after the laminectomy, and was still completely cured thirteen years later.

One of the patients who died had had a spine fusion two years previously, the meninges were found to be thickened at the laminectomy, and he died twelve years after operation, of pulmonary tuberculosis. The other death occurred four months after operation in a girl thirteen years old. A laminectomy alone was done and therefore the case should not be included in this series. The duration of the disease and of the paraplegia in the two patients who failed to improve, was at least seven years in one and ten years in the other. It would seem from this small group of cases, therefore, that if anything is to be accomplished by a laminectomy it must be done early. It is believed that in all cases operated upon it should be combined with a spine fusion. In all cases it was found that the bony spinal canal was large enough, the paralysis being caused by localized abscess in the meninges or due to the reaction of the disease in them.

Various other complications, including pulmonary tuberculosis and involvement of joints, are tabulated below. It is interesting to find that of twenty-eight cases of tuberculosis of other joints occurring in conjunction with that of the spine, fifteen, or fifty-four per cent., became quiescent following the spine fusion. It would seem that the number of cases of pulmonary tuberculosis discovered before operation is too low, and that had more expert physical examination been made and x-rays taken, more cases would have been discovered. It is our custom now to x-ray the lungs in every case.

TABLE 10

COMPLICATIONS

	Number of cases	
Pulmonary		5
Joints		
Upper		5
Shoulder	1	
Elbow	2	
(Note: One had both elbows involved.)		
Carpus	2	
Lower		23
Hip	12	
Knees	8	
Ankles	3	
(Note: One had both ankles involved.)		
Miscellaneous		7
Rib	1	
Sternum	1	
Orchitis and tongue	1	
Pleurisy-peritonitis	1	
Kidney-peritonitis	1	
Dactylitis	2	

Patients were classified as cured only when the deformity showed no further increase, when it appeared both from physical examination and x-ray that the fusion was solid, that there was no activity of the disease, and that the general health of the patient was good. As previously stated,

a long period of follow-up was considered necessary. One hundred and fifty-seven of the 181 cases were followed for five years or longer. Two of the cases considered as cures have small open sinuses eight and ten years after operation, but there is no indication either from physical examination or x-ray that there is an active lesion of the bone. It is believed that these are instances of persistence of the infection in the walls of the sinuses, independent of a bone lesion. Four cases with paraplegia are included as cured, from the standpoint of tuberculosis of the spine. In all of these cases the paraplegia was present before operation and did not disappear afterwards, although there is every indication that the disease in the spine is healed. In the list of deaths are included ten patients who were cured of their spinal tuberculosis and who died of some other cause, such as cardiac disease, pneumonia, pulmonary tuberculosis, etc. Adding these cases to the group of cures would bring the total to 191 and the percentage to seventy-four and six-tenths. In all probability some of the group of thirty cases with a short period of follow-up, in whom the result was doubtful, would belong in the class of cures if they could be found.

Deformity was estimated entirely by tracings made from a lead tape. Unfortunately, many of the early x-rays had been discarded. Omitting those patients in whom the result was doubtful or who died, the deformity was found to be the same or less after operation in 123, or seventy-three per cent. There was an increase in deformity after operation in forty-four cases; this was severe in fifteen, and in these cases the cause was pseudarthrosis or failure of fusion in five, new foci of disease in two, and inadequate extent of fusion in eight. It is the rule to include two healthy vertebrae above and below the area of disease, but in a few cases, through error, this was not done. In cases with an extensive destruction before operation, some increase in deformity is to be expected for a few months afterwards, but when this continues for a longer period failure of fusion is always suspected, and unless there is some good reason for not doing so, an exploratory operation is done. Part of the increase of deformity is probably due to the contraction of scar tissue as the disease heals. X-ray examination is unreliable for demonstrating failure of fusion. In many of the cured cases late x-rays show fusion of the bodies in the diseased areas, and it seems quite probable that this is the final result in the great majority.

More than one operation was performed in thirty-nine cases. In one case the operation was done in two stages at an interval of two weeks, and another patient had been operated upon in another hospital. The reason for the second operation was paraplegia in three cases, increasing deformity in twenty-five, and continuation of symptoms in twelve. It was found that the previous area of fusion was too short in fifteen, and that there was failure of fusion in twelve. This is four per cent. of the total. The area of non-union in all instances was a narrow crevice extending across the column of bone and occupied by dense fibrous tissue. In some cases it was so small that it could be found only by the most careful examination, and yet the slight degree of motion which it permitted was sufficient to

cause increase in deformity and continuation of symptoms. It is our firm conviction that whenever non-union occurs it is due to faulty technique. Twenty-four of the reoperated cases, or seventy-five per cent., were cured, two were not cured, and seven died. Eight cases when last heard from were not cured. Two had paraplegia and could be followed for only two and three years. Six patients had discharging sinuses. One is now under treatment at the hospital, and is in poor condition. Two were lost sight of at the end of one year, another was traced for three years, one for six years, and one for nine years. Two of these patients had an inadequate area of fusion and would not consent to another operation. One patient was an adult Italian with tuberculosis of the knee as well. All the members of this group were in poor condition at the time of their operation.

The percentage of patients who died, omitting the unknown group, was twenty-six and two-tenths. It is seen that eighty-eight per cent. of the deaths were caused directly by tuberculosis or by some closely associated condition, such as chronic suppuration. The average age at operation of the patients who died from pulmonary tuberculosis was eighteen years. This is a complication seen more frequently in adults, whereas tuberculosis of other joints and generalized tuberculosis are met with much more frequently in children.

TABLE 11

CAUSES OF DEATH

1. *Generalized Tuberculosis*	25 cases
Average age at time of operation—11	years 10 months.
Average time after operation — 1	year 7 months.
Of these, meningitis was present in 20 cases.	
Average age at time of operation—11	years 2 months.
Average time after operation — 1	year 10 months.
2. *Chronic Suppuration*	14 cases
(*a*) Amyloidosis 7	cases.
Average age at time of operation—12	years.
Average time after operation — 4½	years.
(*b*) Secondary Infection 7	cases.
Average age at time of operation—24	years.
Average time after operation — 1	year 2 months.
3. *Pulmonary Tuberculosis*	8 cases
Average age at time of operation—18	years 7 months.
Average time after operation — 3	years 10 months.
4. *Pneumonia*	9 cases
Average age at time of operation— 9	years.
Average time after operation — 2	years.
5. *Miscellaneous Causes*	11 cases
Cardiac disease 3	
Septic embolus 1	
Tuberculous nephritis 1	
Tuberculous peritonitis 1	
Otitis media 1	
Unknown 4	

Disseminated tuberculosis accounted for twenty-five deaths. Twenty of these patients had tuberculous meningitis. The average age at operation of these patients was eleven years, and the average interval between operation and death was one and six-tenths years. Only three, or one and six one-hundredths per cent., of the series developed generalized tuberculosis within two months after operation. This refutes the argument that opera-

tions on tuberculous joints are likely to disseminate the disease. The incidence in this series, and in all other series of operations on tuberculous joints studied in this hospital, is no greater than in other groups not operated upon, and the number of cases occurring soon after operation is so small that they must be regarded as a coincidence.

There were fourteen deaths from chronic suppuration and secondary infection, of whom seven had amyloidosis. All of the patients who died of amyloid disease had psoas abscesses before operation, and, with one exception, all had discharging sinuses before operation. Of the seven cases in which death was attributed to secondary infection, five had abscesses in the back, one a psoas abscess, and one an abscess in the region of the hip joint, all with discharging sinuses. The average time between operation and death in these cases was one year and two months.

One of the most important studies is that of the operative mortality. In this series, including those in which more than one operation was performed on a single patient, 325 spine fusions were done on 286 patients. Three patients, or nine-tenths of one per cent., died from the operation. The mortality for all the operations from 1911 to 1920 inclusive was five-tenths of one per cent. These three patients were all poor risks. One was a male, thirty-four years old, who died in eight hours from myocardial failure. A boy seven years old, who also had pulmonary tuberculosis, died at the end of four days of acidosis and pneumonia. The third case, a man twenty-nine years old, died four days after operation of an embolus. It should be stated that it is now our custom to use ethylen or local anaesthesia in all cases with pulmonary complications. Acidosis can be dealt with much more effectively today with intravenous administration of glucose and insulin. More care is now being taken to get the patients in as good condition as possible before operation.

SUMMARY

1. In the six years from 1915 to 1920 inclusive, 286 cases of tuberculosis of the spine had 325 fusion operations at the New York Orthopaedic Dispensary and Hospital.

2. Thirty cases were excluded because the period of follow-up was short and the result was doubtful.

3. One hundred and eighty-one patients, or seventy and seven-tenths per cent. of the remainder, are living and cured Ten other patients were cured of tuberculosis of the spine, but died of other causes This makes the total number of cures 191 and the percentage seventy-four and six-tenths.

4. Eight patients, or three and one-tenth per cent., were not cured.

5. Sixty-seven patients, twenty-six and two-tenths per cent., died. Eighty-eight per cent. of the deaths were due to tuberculosis or directly related causes.

6. The operative mortality was only three, or nine-tenths of one per

cent., all of whom were poor risks. For the entire number of 534 operations performed from 1911 to 1920 it is only five-tenths of one per cent.

7. These 286 patients represent practically the entire number of cases seen at the Orthopaedic Hospital during this period. The cases were not selected, and, almost without exception, no one was refused operation. These patients in the main were of the poorer class, coming from unfavorable surroundings, and after operation returned to the same environment.

CONCLUSIONS

It seems undoubtedly true that the results in this series would have been better if the cases had been operated upon early.

Analysis of these facts shows that mortality and lowered resistance to tuberculosis is directly proportionate to the number of local manifestations of the disease. The percentage of deaths in the group having two spinal foci was thirty-six, as contrasted with twenty-six in the entire series. Fifty per cent. of the series complicated by hip-joint tuberculosis had a fatal termination, and all of those who had tuberculous peritonitis or nephritis died.

In that group in which nature had made an attempt at elimination of motion by an area of natural fusion of posterior vertebral elements there were only thirteen per cent. of deaths, and not one was due to tuberculous meningitis. Thus it would seem that early elimination of motion in all diseased joints would increase the patient's resistance.

2. Any treatment to be most effective in vertebral tuberculosis must be applicable to children, as most cases occur in childhood. This series and the previous one offer abundant proof that children are the most favorable cases for operation. Fusion takes place more rapidly in them and their recuperative powers are better[2].

The enforced inactivity over long periods of time so commonly used in the treatment of this disease in children is detrimental to their physical and psychological development. Furthermore, there is no justification for the hope that all the diseased joints become fused by such means.

The diagnosis of tuberculosis of the spine should be possible very early by x-ray and physical examination. The hope of improving the results in the future depends upon the education of the medical profession in the methods of early diagnosis and upon their urging immediate operation.

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2. Smith, A. DeF.: A Study of Autopsy Specimens of Fused Spines and of Cases Subjected to Secondary Operation. J. Bone and Joint Surg., V, 507, July 1923.

DISCUSSION

Dr. Edwin W. Ryerson, Chicago: It is rather difficult, after listening to a paper so entirely statistical in nature, to pick out many points for discussion. It is proper

to say that only by such careful studies of a large series of cases and by so careful an analysis as we have heard to-day can we properly evaluate the various methods of treatment.

For a great many years I have been an advocate and an earnest advocate of the operative fixation of tuberculous joints wherever situated. For some years following 1911 a great many of us enthusiastically operated upon all of our tuberculous spines of whatever age. There was then a wave of sentiment against operation on young children's spines whether by the Albee or Hibbs method, based upon good but actually false observations. We found that many cases had increase of deformity after operation. We did not realize that the reason was lack of continuous and long continued fixation.

I have not yet arrived at the stage where I like to operate upon very young children. The bone itself is not strong and may bend. I am gradually coming to believe that, when the diagnosis of tuberculous spondylitis is made, we should ankylose the vertebrae as soon as possible. It is very instructive to hear from Dr. Hibbs the high proportion of patients in whom an attempt at natural fusion of the laminae was present at the time of operation. It shows that the work in this operative field is founded on a sound basis. Those of us who for thirty years have been seeing cases of spinal tuberculosis, realize that only by fusion of the affected vertebrae can a cure be established. Of course, there is a definite mortality. There is a mortality from any operation, no matter how simple. It will be found that the mortality decreases in proportion as the operation is earlier performed.

Another interesting point is that in some of these cases, amounting to four per cent., a failure of fusion was observed after operation. In Dr. Hibbs' clinic this operation is very beautifully performed. It is done better there than in almost any place in this country. It is significant that four per cent. failed to obtain union, and Dr. Hibbs regards this as an indication of imperfect technique. I think as time goes on, most of us, after performing the Hibbs operation, will take an osteoperiosteal graft and lay it across the affected area. I began this years ago when I first began experimenting with the Hibbs method. We do not do it in all cases but it seems wise. We may use the Hibbs technique or the Albee technique, but in my opinion the Hibbs technique is the better, that is, the Hibbs operation supplemented by an osteoperiosteal graft.

PREVENTION OF ADHESIONS TO TENDONS IN THE HAND AND WRIST

With Report of Two Cases

BY GEORGE D. MARSHALL, M.D., KOKOMO, INDIANA

From the point of view of ultimate function, the question of adhesions between tendons and adjacent tissues and between tendons themselves, following injury to the tendon or tendon sheath, has always been a source of worry to the surgeon.

A great deal of investigative work has been done with the purpose of working out some procedure to prevent adhesions developing in the peritoneal cavity following operation. The methods used have included the introduction of vaselin, olive oil, catgut, Cargile membrane, acacia-gelatin mixture and other agents, but their application has not yet proved altogether satisfactory. To a lesser degree research has also been carried on with a view to preventing adhesions to the tendons of the hand and wrist where limitation of motion of the hand and fingers is liable to occur through the formation of attachments between the tendons and surrounding tissues. In the healing of infections, adhesions are quite constant, often rendering necessary secondary procedures which are designed to remove the adherent scar and restore mobility. In these secondary operations the tendon sheath often must be completely removed through a great deal of its length with the scar, thereby denuding the tendon and making it possible for the tendons to become adherent to each other as well as to the overlying structures. It is in this situation that prevention of attachment between new forming scar and tendon is all important, so far as ultimate function is concerned.

To prevent the formation of these adhesive attachments between tendons and between tendons and other structures, it occurred to the writer that if, during the period of healing following excision of the scar, part of the tendons not protected by a sheath could be effectively separated, then adhesions between tendons might be prevented; also, if the tendons could be prevented from adhering to each other, then the same agent interposed between the overlying tissue and tendons would insure entire freedom from adhesions, thus giving free and unimpaired motion.

The following method was therefore devised, and has been used successfully by the author in many cases: Each tendon is surrounded with plain catgut, the strands of which are laid parallel to the tendon, thus forming a fence-like protection which does not allow any tissue to come in direct contact with the tendon. The catgut is only slightly irritating but will remain long enough to prevent adhesions before being absorbed and will not

interfere with motion or be displaced during movement of the tendons. Infection, of course, has to be guarded against carefully, as it would preclude any hope for success.

The following two cases are illustrative of the procedure:

CASE 1. A plate-glass worker, three years before coming under observation, received two rather deep lacerations across the dorsum of the right wrist, one just distal to the styloid of the ulna and the other about one and one-half inches above. The tendon of the extensor carpi ulnaris apparently was divided by both lacerations and not united at the original closure of the wounds. The tendons of the extensor communis digitorum to the fourth and fifth fingers were severed and a firm band of scar tissue had formed across the dorsum of the wrist at the site of injury. Following the scar formation there was marked interference with flexion of the wrist and fingers; circulation in the hand was poor, and the patient complained of constant pain in the hand.

Operation. The scar was dissected entirely free and removed and the severed ends of the tendons were freed and identified. The segment of the tendon of the extensor carpi ulnaris lying between the two wounds was replaced by several silk and catgut sutures which joined but did not approximate the distal and proximal ends of that tendon. The ends of the tendons of the extensor communis digitorum were sutured in apposition. Each tendon was then surrounded with No. 2 plain catgut, the strands of catgut being laid parallel to the tendon and serving to separate the tendons from each other and from adjacent tissues.

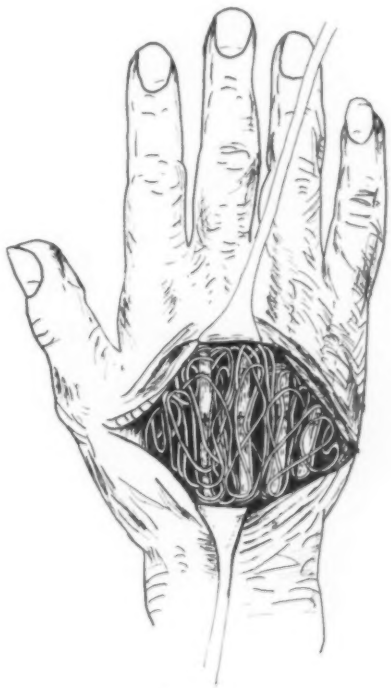

FIG. 1

Illustrates the method of placing catgut about sutured tendons.

A cock-up splint was applied to maintain the wrist and fingers in hyperextension. Passive motion was begun at the end of two days and active motion in two weeks. At the end of four weeks there was practically complete flexion and extension of the wrist and fingers, and the man was able to return to the same work as before injury. Relief from pain was immediate after the operation.

CASE 2. In July 1926, a young man of twenty-six was cut across the dorsum of the right hand with a piece of glass. The tendons of the extensor communis digitorum to the index, middle and ring fingers and the tendon of the extensor indicis proprius were divided. A second laceration on the dorsum of the thumb at the metacarpophalangeal joint severed the tendon of the extensor pollicis longus and lacerated the capsule of the joint. When seen in December 1926, the fingers were held rigidly extended and the thumb held in partial flexion with no power of abduction.

Operation. The tendons on the dorsum of the hand were dissected free and identified. The severed ends were then sutured with silk and the tendons surrounded with No. 2 plain catgut, the strands being laid parallel to the tendon. The tendon of the extensor pollicis longus was freed, the capsule of the joint sutured, and a hole drilled

into the proximal end of the phalanx through which the tendon of the extensor pollicis longus was drawn and sutured. Strands of plain catgut were placed about the tendon as previously described and the skin wound closed.

Massage by the use of a pneumatic vibrator was used two weeks after operation. In six weeks the restoration of function was excellent and the man returned to his work as a truck driver.

The successful results obtained in numerous cases by this method have encouraged the author to offer it as a suggestion worthy of consideration in treating such conditions.

AN ADJUSTABLE SPRING CRUTCH*

BY PHILIP LEWIN, M.D., CHICAGO

When a patient is compelled to depend on crutches for support in locomotion he will, unless the crutch can be adjusted to fit him, be unduly uncomfortable. This, added to the nervous and hesitant frame of mind of the average person in this condition, makes every step taken, particularly at the beginning, a discomfort because of the strain caused by using an unadjusted, rigid crutch.

The patient is taught, or should be instructed, to bear as much weight as possible on the stiffened or rigid arms, and to depend on the axillary support as little as he can, to prevent the unpleasant feeling of tingling fingers which in turn may be followed by temporary paralysis or limitation of joint movement in the hands.

One disadvantage presented by the ordinary crutches is that they are manufactured only in standardized sizes, — such as forty-eight inches, fifty inches, fifty-two inches, representing the distance from the axilla to the ground. The distance from the top of the crutch to the hand piece is also standardized, so that most manufacturers provide a forty-eight-inch crutch with an arm length of fifteen and three-eighths inches and the fifty-inch crutch with an arm length of sixteen and one-quarter inches.

FIG. 1-A
Improper use of crutches.

FIG. 1-B
Proper use of crutches.

The arm lengths of men of the same height vary considerably. The only possible method of adjustment on the present rigid crutch is by cutting off the bottom, which does not affect the arm length at all, and necessitates the user resting his weight on the crutch top or under the axilla, or unnecessarily spreading the crutches out some distance laterally from his feet as shown in Figure 1-A, all adding to the discomfort, uncertainty, and insecurity of their use, as they are in constant danger of slipping. Most crutch

*This crutch was devised by Mr. John A. Weis. The writer has not assisted him in any manner except to bring it before the orthopaedic profession.

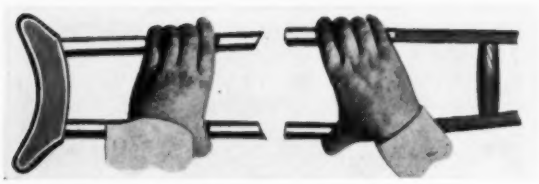

FIG. 2
Telescoping sleeves

users are compelled to walk in this unsafe and uncomfortable manner. No practical solution of this problem was found until Mr. Weis made a proper adjustment both for arm length and height, as illustrated in Figure 1-B.

To accomplish this he has devised and constructed the crutch in two separate parts, as shown in Figure 2. The metal sleeves of the upper part of the crutch telescope over the sleeves which cover the upper ends of the bifurcation of the lower part of the crutch. By compressing the upper ends of the bifurcation and directing same into the telescoping sleeves of the upper part, a frictional connection can be made within a few seconds. The crutch can be taken apart for the purpose of adjustment within a few seconds by compressing the upper ends of the bifurcation. When the crutch is assembled in the above manner, it is "fool-proof" and does not come apart.

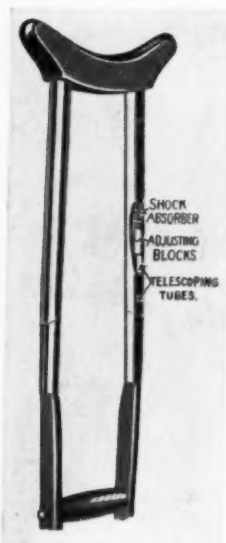

FIG. 3
Shock absorbing recoil springs in the telescoping sleeves.

Arm and height adjustments can also be easily accomplished by simply removing or adding some of the plugs in the upper sleeve of the crutch as shown in Figure 3.

The shock-absorbing, recoil springs placed in the telescoping sleeves, shown in Figure 3, lessen the impact and add considerably to the comfort, particularly when the crutch user is compelled to walk down stairs or step down from the curbstone to the pavement, when the body drops into the crutch, as it were. Special rubber top pieces with cells on the under side, making a soft resilient pad as well as acting as a means of keeping the top of crutch from slipping away from the arm, can be furnished with the crutch. The principle involved in this arm cushion is that of the so called non-communicating air cells, and of a similar nature to the ones very successfully used for the automatic gun cushions during the War. These pads can be almost as quickly and easily attached to the tops of crutches as the rubber tips to the bottoms. This cushion will be known under the name of "SAMARITAN" Crutch Pad, and will add greatly to the comfort in

connection with the ordinary, and particularly so with the adjustable spring crutch (See Fig. 4).

The construction of the crutch is simple. There are no slots or protruding stops,—no screws or knots that may work loose. There is nothing to get out of order, and the crutch can be used over and over again by patients of various heights and arm lengths.

The cost of the crutch is not prohibitive. It has been patented in the United States, foreign patents are pending. Arrangements have been made with the J.W. Ladd Manufacturing Company, of Hill, N. H., for the manufacture and distribution in the United States. The advantages of the adjustable spring crutch over the unadjustable present rigid form in general use are self evident.

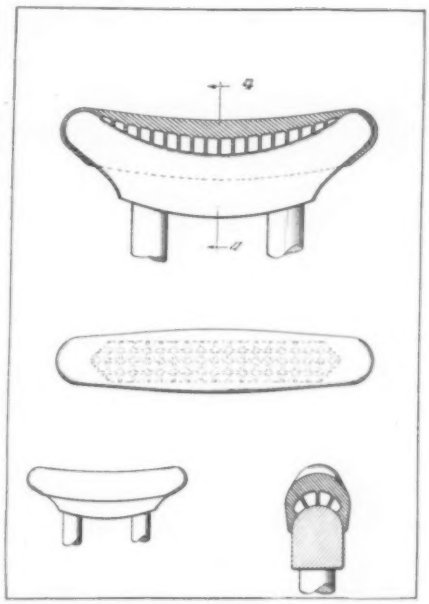

FIG. 4
Crutch pad with cells on under side.

NOTE: Most patients are directed to "use crutches" with no instruction. The progression, if both legs are to be used, should be as follows:

1. put right crutch forward,
2. put left foot forward,
3. put left crutch forward,
4. put right foot forward,

i. e. first a crutch; then the opposite foot. All steps with crutches and feet should be of equal length instead of a long and then a short step.

Miss Wilhelmine Wright of Boston has written an interesting article on "Crutch-Walking as an Art" in the American Journal of Surgery, New Series, I, 372, December 1926.

END RESULTS OF ARTHROPLASTY OF THE KNEE*

BY WILLIS C. CAMPBELL, M.D., MEMPHIS, TENN.

A report was made in 1925, at the request of the Program Committee of the American Orthopaedic Association, on the end results of arthroplasty of the hip. In consequence, it was thought that a similar clinical demonstration of the end results of arthroplasty of the knee and the observations which have been made of the evolutionary physiological process in the reconstruction of a new joint would be of interest. There has been much speculation as to the nature of the reconstructed joint but very little evidence has been acquired as to what actually occurs after arthroplasty.

This report is based not only upon the knowledge acquired in the study and compilation of 111 arthroplasties of the knee, but more particularly upon the observations which have been made upon twenty-two arthroplasties in which from four to nine years have elapsed since operation.

Restoration of function by arthroplasty and subsequent treatment is a more intricate problem in the knee than in other joints. This is due to the fact that the knee is the most complex articulation in the body and is dependent for stability upon ligamentous support on all four sides and in the interior of the joint. However, more difficulty has been actually encountered in the hip than in the knee, and the percentage of successful results has been greater in the knee than in the hip. This is probably due to the incident extensive osteomyelitis which is more prevalent in the pyogenic infections of the hip than in other joints, as the capsule of the hip joint encloses the greater portion of the neck of the femur, which is rendered an easy prey to invasion by all infectious processes within the joint.

Arthroplasty consists not only in the prevention of osseous fusion between the articular surfaces, but also includes the reconstruction of all the component parts of the articulation,—as, muscles, tendons, ligaments, and fasciae, with the object of restoring or substituting physiological function. The operation itself is but the first step in the reestablishment of function, which must be followed by a carefully planned after-treatment to reeducate the atrophic muscles. Unless a durable, stable joint, which will stand average daily use, is restored, a joint ankylosed in the most useful position is far more serviceable.

The operative technique of Murphy[1], as recently advocated by Putti[2], is well known, for a review of which reference can be made. However, this report is based upon the procedure which was described by the author before this association in 1921, since which subsequent reports have been made as new data of practical interest has been acquired. Only those in

*Read at the Annual Meeting of the American Orthopaedic Association at Washington, May 1, 1928.

whom ankylosis was due to acute pyogenic infection are considered here. The principle of this procedure consists in the reconstruction of a simple hinge joint without regard to anatomical contour,—for instance, one convex condyle is formed upon the lower extremity of the femur, one shallow concave articular surface on the upper extremity of the tibia and the patella well denuded; the primitive embryological joint is reproduced as far as possible by an interposition of an almost complete sac of transplanted free fascia lata from the opposite thigh. However, reference can be made for detailed description of technique to the last report read before the Southern Surgical Association in December, 1927[5].

As previously stated in former contributions, animal experiments are of comparatively little value in arthroplasty, as it would be exceedingly difficult to secure a sufficient number of animals with ankylosed joints or to induce ankylosis in a large number of animals for experimental purposes; and even if such were feasible, the intelligent cooperation absolutely necessary in the cultivation and restoration of function could not be secured. In consequence, all practical knowledge of value has been acquired upon the human subject. Therefore, our remarks will be entirely confined to the observations of specimens and clinical data on the living human subject to determine the histological, physiological, and clinical aspects of arthroplasty of the knee.

The counterpart of arthroplasty is often demonstrable clinically and by the roentgenogram as a result of certain affections of the joints,—as

FIG. 1

Case 2. Nine years after arthroplasty of knee, showing degree of flexion.

FIG. 2

Same as Figure 1, showing extension.

FIG. 3

Photograph of knee in Case 4 seven years after arthroplasty for ankylosis following compound fracture, showing degree of flexion.

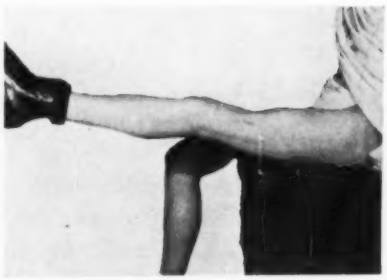

FIG. 4

Same as Figure 3, showing extension.

trauma, tuberculosis, and pyogenic infections. In such conditions, a joint may be practically destroyed, but a good functional result salvaged by nature. Also a somewhat analogous condition is observed in those ununited fractures in which a pseudarthrosis has been induced. Specimens removed at operation show a definite joint, which is covered by fibrocartilage. A lubricating fluid may be present, but no definite synovial membrane can be demonstrated.

There has been very little opportunity afforded to observe the histological evolution of the reconstructed joint, as the procedure defined as arthroplasty is comparatively new and postmortem findings are of great rarity. Our actual

FIG. 5

Case 11. Six and one-half years after arthroplasty of knee, showing degree of flexion.

FIG. 6

Same as Figure 5, showing complete voluntary extension.

knowledge of histological specimens has been made by Baer and Sudhoff, to which the author desires to contribute the present report. Baer[3] describes his findings in four joints which he opened following arthroplasty with the use of chromicized pig's bladder as the material of interposition, but he does not specify the joints which were explored, indications for exploration, or what the status of the joint was as regards function and durability. Chromicized pig's bladder as a material for interposition was routinely employed. His findings were as follows:

"In the joints the membrane had been absorbed, but a space following in the outlines of the joint persisted in each case. The lining of the cavity was perfectly smooth. The microscopic sections made from the walls of these newly formed joints were as follows:—The chromicized bladder had been infiltrated by round-cell infiltration from the side next to the denuded bone. The round cells permeated the membrane, which at first became quite cellular in character. These cells finally became diminished in number and the tissues adherent to the bone were changed into a fibrous mass. The cells toward the joint side became flattened out, but there was no distinct endothelial lining to the joint. The fibrous tissue on the adjacent bones showed no tendency to coalesce. A very noticeable feature was the entire absence of the giant cells which one generally sees in the tissue surrounding any foreign body. From these findings we would conclude that the membrane is transformed into a fibrous tissue which covers the denuded bone, and that a joint-like space is formed with fibrous walls, similar in all respects to the walls of a cavity encysting a foreign body."

Sudhoff[4] has secured the only postmortem report in a functional joint, an elbow, which is the only opportunity that has been afforded for a minute dissection after arthroplasty. Two years after a successful arthroplasty of the elbow, in which the arc of motion was between 45 and 165 degrees,

FIG. 7

Case 13. Five and one-half years after arthroplasty of knee, showing degree of flexion.

FIG. 8

Same as Figure 7, showing complete extension.

the patient died of an intercurrent affection in no way related to the arthroplasty or the former infection of the joint. Autopsy showed the articular ends were smooth in all parts and covered with white fibrous sheets of connective tissue two or three millimeters in thickness, which was attached to the cortex. The fat fascia could not be recognized.

At points of greatest pressure there were bluish-white areas resembling cartilaginous tissues. The joint space in the anterior portion was interrupted by a septum which formed a bursal cavity. Microscopically, the capsule consisted of thick connective tissue, poor in cells; the bursal lining contained no endothelial cells; however, there was a profusion of large cells found here and there lining the wall. The articular plates were made up of fibrous tissue, poor in cells, and blood vessels; and contained here and there connective tissue cells and nests of hyaline cartilage. The cartilage cells appear to have had their origin in the bordering marrow and the periosteum. The connective tissue fibers in places pass from the marrow interstices into the articular sheets.

The author has had occasion to incise three knees after arthroplasty, one of which will be reported in detail, as excellent function resulted for a sufficient length of time to determine the status of the reconstructed articulation, the history of which is as follows:

The patient was a girl, age twenty-two years, who had acute infectious arthritis, pyogenic origin, in January 1925, followed by complete bony ankylosis of the left knee. Routine arthroplasty was performed on November 22, 1926. She had an uneventful recovery, but at the end of one year she complained of slight catching or locking of the joint and returned for further treatment. On examination at that time there was about ninety degrees flexion and complete and powerful extension. The patient walked without limp; there was no undue laxity. An exploratory operation was carried out on December 8, 1927.

An internal lateral incision was made into the left knee through the former operative scar. The skin and superficial fascia were found to be normal. The capsule and periarticular structures were much increased in thickness, possibly about one inch. On passing through the capsule, a definite joint space about one-half the capacity of the normal knee was reached, which extended between the articular surfaces of the tibia and femur well under the patella and quadriceps tendon. A few adhesions were found between the quadriceps tendon and the posterior wall of the cavity, but these did not interfere in any way with movements. A very small amount of joint fluid of straw color was observed; this was less than is found in the normal joint, but was sufficient for lubrication. The articular surfaces were smooth, glistening, regular, and covered with a dense layer of fibrous tissue resembling in every detail the free transplant of fascia lata which was interposed at the original operation.

Sections were removed from the inner aspect of the articular surface of the lateral condyle and from the inner surface of the capsule for microscopic examination. The section from the articular surface was composed of three layers, or strata, from without inward,—a dense fibrous layer, well defined fibrocartilaginous layer, and bone. The fibrous layer contained chiefly dense but irregular fibrous tissue with comparatively few cells, but the appearance of this layer had evidently been affected by the acid employed as a decalcifying agent. Beneath the fibrous layer was a well defined and very regular strata of fibrocartilage with a homogenous matrix. The cells had been to a large degree destroyed by the acid necessary to preparation, but there were numerous small vacuoles from which the cells had evidently been displaced. At places there were many fibrous

bundles passing from the cartilage to the osseous layer, and occasionally evidence of a well defined fibrous layer between the cartilage and bone, thus in some places making four layers. The osseous strata was composed of normal cavernous bone. In the section from the lining of the cavity were evidences of well defined villi, which were composed of premature fibrous tissue of a very cellular nature. The surfaces were covered with a definite layer of cells which were very irregular in shape and could not be designated as endothelium and were probably young fibroblasts. It is possible, but not probable, that there may have remained remnants of the normal synovial membrane which had not been destroyed by the pyogenic infection.

From these findings it is quite evident that a new functional joint was formed. In all probability, the investing membrane becomes in time absorbed at the point of greatest contact, being substituted over the articular surfaces by cartilage. In fact, a complete new joint with synovial membrane is formed, which, to some extent, differs from the normal structure. The most interesting feature is that the fascia lata had apparently remained intact and had acted as a permanent investing membrane which is contrary to all former deductions based upon animal experimentation.

Two other joints were incised by the author on account of undue laxity. In both there was excellent voluntary motion but walking was facilitated by aid of a brace. In both there was a distinct joint cavity with joint fluid. In one the specimen was unfortunately lost in transmission to the laboratory, while in the other the observations were practically the same as the case reported.

A series of roentgenograms after arthroplasty demonstrates that there is a new joint between the femur and tibia and between the patella and femur; that for a period of three to six months after operation osteoporosis, or bone atrophy, usually is present, after which osseous structure returns to normal. In four there was a definite flattening and sloughing off of a small portion of the external condyle. This may be due to uneven distribution of weight by the removal of too much bone

FIG. 9

Photograph of knee in Case 22 four years after arthroplasty, showing degree of flexion.

FIG. 10

Same as Figure 9, showing active extension.

FIG. 11

Photomicrograph of specimen removed one year after arthroplasty of knee, showing layer of dense fibrous tissue containing few cells, and closely attached to an underlying cartilaginous layer, which in turn is attached to cancellous bone.

FIG. 12

Photomicrograph of specimen from arthroplasty of knee, showing formation of villus, the surface of which is covered by a cellular membrane, probably resulting from the remains of the synovia.

from the internal condyle in an effort to prevent valgus, or possibly there may have been an impairment of the circulation by too extensive dissection of the lateral ligaments, also weight having been borne before structure had returned to normal could easily depress or flatten the surface if osteoporotic. In only a very small number of cases was there extensive reaction by osseous proliferation, or osteo-arthritis, but when present was found to usually follow mild infection. This reaction was found to be a sequela in those cases of an acute infectious arthritis in which there had been a greater degree of osteomyelitis than usually occurs. The statement has been made often that osteo-arthritis, or osseous proliferation, is common in joints reclaimed by arthroplasty, but from these observations in the knee the evidence to the contrary is preponderant.

There may be no definite relation between the efficiency of the joint and the appearance as demonstrated by the roentgenogram. An inefficient joint may show an even contour or a good functional and durable joint may indicate the reverse. However, those with a well balanced, smooth and even articulation are in general the best functional joints.

Estimates of the value of arthroplasty cannot be intelligently made by a gross compilation of records, as there are so many factors which may materially affect the end results. Therefore, cases should be divided for analysis as follows:

TABLE 1

Case No.	*Sex*	*Age at Operation*	*Date of Operation*	*Pain*	*Walking Up Stairs*	*Walking Down Stairs*	*Walking Distances*	*Stability*	*Degree of Motion*	*Brace*	*In Comparison to Previous State*	*Present Occupation*
1	Female	21	5- 6-19	None	Excellent	Excellent	Excellent	Excellent	120	No	Excellent	Housewife
2	Female	22	10-14-19	None	Difficult	Difficult	Excellent	Excellent	45	No	Excellent	Nurse
3	Female	19	11-29-20	None	Excellent	Excellent	Excellent	Excellent	100	No	Excellent	Telephone Operator
4	Male	20	4-18-21	None	Excellent	Excellent	Excellent	Excellent	120	No	Excellent	Farmer
5	Female	31	11- 1-21	None	Excellent	Excellent	Excellent	Excellent	90	No	Excellent	Housewife
6	Male	14	3- 2-22	None	Difficult	Difficult	Excellent	Excellent	40	No	Excellent	Student
7	Female	29	3- 4-22	None	Difficult	Difficult	Difficult	Lax	140	No	Good	None
8	Female	36	4-12-22	Slight	Difficult	Difficult	Difficult	Lax	100	No	Good	Store Clerk
9	Female	19	4-14-22	None	Excellent	Difficult	Excellent	Excellent	90	No	Excellent	Teacher
10	Female	20	6-14-22	None	Excellent	Excellent	Excellent	Excellent	80	No	Excellent	Teacher
11	Female	16	8- 2-22	None	Excellent	Excellent	Excellent	Excellent	90	No	Excellent	Waitress
12	Male	22	8-10-22	None	Excellent	Excellent	Excellent	Excellent	90	Yes	Excellent	Barber
13	Female	22	11-13-22	None	Excellent	Difficult	Excellent	Excellent	65	No	Excellent	Secretary
14	Male	27	5-16-23	None	Excellent	Excellent	Excellent	Excellent	90	No	Excellent	Presser
15	Female	28	11-26-23	None	Excellent	Excellent	Excellent	Excellent	90	No	Excellent	Housewife
16	Female	24	1-15-24	Occa.	Difficult	Difficult	Difficult	Lax	90	No	Failure	Housewife
17	Male	25	3-10-24	Occa.	Difficult	Difficult	Difficult	Lax	120	No	Failure	Farmer
18	Female	16	4-16-24	None	Excellent	Excellent	Excellent	Excellent	45	No	Excellent	Servant
19	Female	31	4-28-24	Slight	Difficult	Excellent	Excellent	Excellent	90	No	Excellent	Housewife
20	Female	18	5- 2-24	None	Excellent	Excellent	Excellent	Excellent	120	No	Excellent	Housewife
21	Male	50	5-28-24	Slight	Difficult	Difficult	Excellent	Excellent	45	No	Failure	Carpenter
22	Male	30	9- 1-24	None	Excellent	Difficult	Excellent	Excellent	90	No	Excellent	Chauffeur

(1) Ankylosis in young adults as the result of an acute pyogenic infection confined to a single knee, the joint being in the position of extension or in not over forty degrees flexion.

(2) Ankylosis as a result of acute pyogenic infection in malposition, with flexion over eighty degrees.

(3) Multiple ankylosis of two or more joints as a result of pyogenic invasion.

(4) Ankylosis as a result of virulent osteomyelitis extending through the joint, involving the shaft of all bones comprising the joint or participating therein.

(5) Multiple ankylosis as a result of, or during the course of, progressive arthritis of a low-grade type, as in rheumatoid arthritis or arthritis deformans.

(6) Ankylosis in children as a result of pyogenic infection.

A detailed survey of 111 arthroplasties conforming to this classification was made before the Southern Surgical Association[5] to which reference can be made. In this report there is a material variance in the percentage of successful results in the different groups. For instance, in Group 1 there were from eighty to ninety-four per cent. successful results while in Group 4 there were one hundred per cent. failures.

The object of the present report is to determine the value of arthroplasty as to the durability and efficiency of the reconstructed joint after the elapse of sufficient length of time. Therefore, a careful survey has been made of twenty-two cases with a practical range of voluntary motion, in which from four to nine years have elapsed since operation, as graphically illustrated in the accompanying tables:

Table 1 may be explained to better advantage by Table 2, as follows:

TABLE 2

No. of Cases	Age	Sex	Time Elapsed Since Operation	Pain	Walking Up Stairs
22	14 to 50 years Average 20.5 yrs.	Male 7 Female 15	4 to 9 yrs.	Occasional 2 Slight 3 None 17	Difficult 8 Satisfactory 14

Walking Down Stairs	Walking Distance	Stability	Average of Motion	Brace	Comparison before and after by Patient
Satisfactory 12 Difficult 10	Satisfactory 18 Difficult 4	Stable 18 Slight laxity 4	45 to 140 degrees Average 89 per cent.	1	Failure 3 Excellent 19

As will be noted, the results in seventeen are excellent, with durable and efficient joints, though by no means perfect. Eleven conformed favorably to all questions and were almost normal. The two classed as

"good" were not perfectly satisfactory to the author, but from the patients' point of view are considered excellent.

In conclusion, from the observations which have been made, there is every evidence that a new joint covered with cartilage is developed by functional adaptation. A synovial membrane is functionally restored which secretes lubricating fluid; whether this membrane is lined by endothelial or simple connective tissue cells, which is capable of cell differentiation or metamorphosis, is of no practical difference. In former contributions and from the above survey of twenty-two arthroplasties, definite proof has been submitted that a durable and efficient joint may be secured.

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DISCUSSION

Dr. W. S. Baer, Baltimore: I am very much pleased with the demonstration that Dr. Campbell has brought before us. His results exceed by far anything I have been able to obtain in the knee. We differ as to which joint, knee or hip, is the most suitable for arthroplasty. The hip joint can always be put down as a positive result but Dr. Campbell thinks the knee joint is far more favorable than the hip. We each have our difficulties in the respective joints.

As far as making the joint, I agree with him in certain respects. I do not know why four cases that I have examined which have been operated upon and the causes of which have been studied, afterwards showed a fibrous covering on top of the bone. It must be understood that we are using different materials. Fascia is the one used by Dr. Campbell, membrane by myself in all cases.

With the membrane in the cases that were completely excised, where there was no cartilage left on the surface, where the bone had to be chiseled through and the membrane placed in there, we had a layer of fibrous tissue over the top of the bone, the fibrous tissue becoming flattened out on the surface of the joint itself, which could not be called endothelial cells, but connective tissue cells simply flattened out. There was no new bone formation or cartilage in the bone such as Dr. Campbell has shown. So far as I know, there have been no actual arthroplasties done in animals either by fascia or by membrane to determine that point. Of the series which I tried somewhat recently, all had an epidemic and died during the experiment.

I myself am very much gratified to see so beautiful a collection of arthroplasties of the knee. My own feeling is that one should never promise function of the knee, and I never do in my practice. We get it often, but we do not get it in about ten to eleven per cent. of the cases. We have not done as extensive an operation as Dr. Campbell has. The knee joint is a very difficult joint, and a very complicated joint, and therefore much harder to make an arthroplasty on than the hip. The patella comes down across the knee and the ligaments are closely associated with that as a fulcrum and is very different from what you have at the hip joint. And so you have to contend with an absence of the crucial ligaments, with an absence of the semilunar cartilages and with the lateral ligaments bound down to the lateral surfaces of the joint itself. Personally

I have always felt that a stiff joint is better than a flail joint. Hence, we have never gotten quite so far as Dr. Campbell has and we do not do as much resection as he. Whenever these joints ankylose, they rarely ankylose from absolutely true bone; they ankylose from the capsule and from fibrous tissue along the joint itself,—that is, many of them lose their mechanism in the amount of new bone formation afterwards. That may be due as Dr. Campbell has said to the presence of an old infection in the bone itself. I have had to do them over, however, two or three times on account of the new bone that is produced. I personally do not think I cut away enough of the condyles, which Dr. Campbell says allows better motion.

The after-treatment, to my mind, is the thing we still have to know more about; how to get rid of the contraction of the quadriceps; how to prevent contraction of the capsule, how to prevent adhesion to the other bones.

Dr. Willis C. Campbell, Memphis, Tenn. (Closing the discussion): In answer to Dr. Baer's question regarding results in 111 arthroplasties of the knees, a complete report was made before the Southern Surgical Association, which was published in Surgery, Gynecology and Obstetrics for July 1928. This discussion is based upon the end results with special reference to efficiency, durability, and physiological restoration, as may be demonstrated in twenty-two cases in which sufficient time has elapsed.

REPORT OF A CASE OF SCLEROSING OSTEOMYELITIS ASSOCIATED WITH TRICHINOSIS*

BY GEORGE E. BENNETT, M.D. AND JOHN V. HOPKINS, M.D., BALTIMORE, MD.

The following case report seemed of interest owing to the possibility of its throwing some light upon the etiology of sclerosing osteomyelitis.

The patient, F. Q., male, forty-seven years of age, is an Italian by birth and has, for the past fifteen years, been employed as a coal miner in West Virginia.

The family history is essentially negative. There is no history of tuberculosis, cardiovascular-renal disease, carcinoma, nor of any bone or joint condition.

The past history is negative. The patient is a married man and has four children living and well. His wife has had no miscarriages.

FIG. 1

X-ray of femur taken on admission. Increase in cortex with decrease in medulla.

The present illness started in October 1926, though the patient gives a history of "rheumatism" for the past four or five years. He has had vague pains and aches in various joints and muscles. There has been no history of any acute attack nor of any injury. In October 1926, about one month after a tonsillectomy had been performed for his "rheumatism", he began having pain in the right thigh about three inches above the knee. The pain was rather dull and boring in character and bothered him mostly at night.

In November 1926—one month after the onset of pain—he first noticed a small tumor on the medial surface of the right thigh about three inches above the knee. He was treated by his family physician, who finally made a diagnosis of sarcoma and sent him to the Howard A. Kelly Hospital in Baltimore. He had lost no weight, his work had not been interfered with, and his general condition was excellent.

On admission to the Howard A. Kelly Hospital on June 21, 1927, the patient was observed to be a well developed, well nourished Italian laborer of forty-seven, with a complaint of pain and a swelling in the right thigh. A general physical examination was negative except for a local condition as follows:—

On the medial surface of the right thigh, about three inches above the knee, was found a mass about the size of a golf ball. The skin over the mass was not injected. On palpation there was no increase in local temperature, no fluctuation or pulsations. Slight pain was elicited on deep pressure. The mass was hard and seemed fixed to the femur. It did not in any way interfere with locomotion. No enlarged glands were felt in the groin. An x-ray of the femur (Fig. 1) showed an increase in the cortex of the bone

*Presented at the Annual Meeting of the American Orthopaedic Association at Washington, May 3, 1928.

with a marked decrease in the medulla. An x-ray of the lungs and pelvis proved negative.

The blood picture was normal: hemoglobin 90 per cent., white blood corpuscles 6,900.

Differential:

Polymorphonuclear neutrophils	72 per cent.	Small lymphocytes	18 per cent.
" basophils	0 " "	Large lymphocytes	4 " "
" eosinophils	2 " "	Transitionals	2 " "
		Mononuclears	2 " "

The Wassermann reaction was negative. The blood chemistry was normal. The urine was entirely negative.

A diagnosis of sarcoma of the femur was then made and the patient was treated with radium,—fifty gram hours at five inches over the mass. No reaction was noticed.

After treatment, the patient was discharged from the hospital with instructions to return in one month.

The physical examination at the time of the second admission to the Howard A. Kelly Hospital on July 21, 1927, was practically that of his former admission, except that there was a slight superficial reaction to the radium. The skin over the mass was red and the local temperature was increased, but no enlarged glands were palpable in the

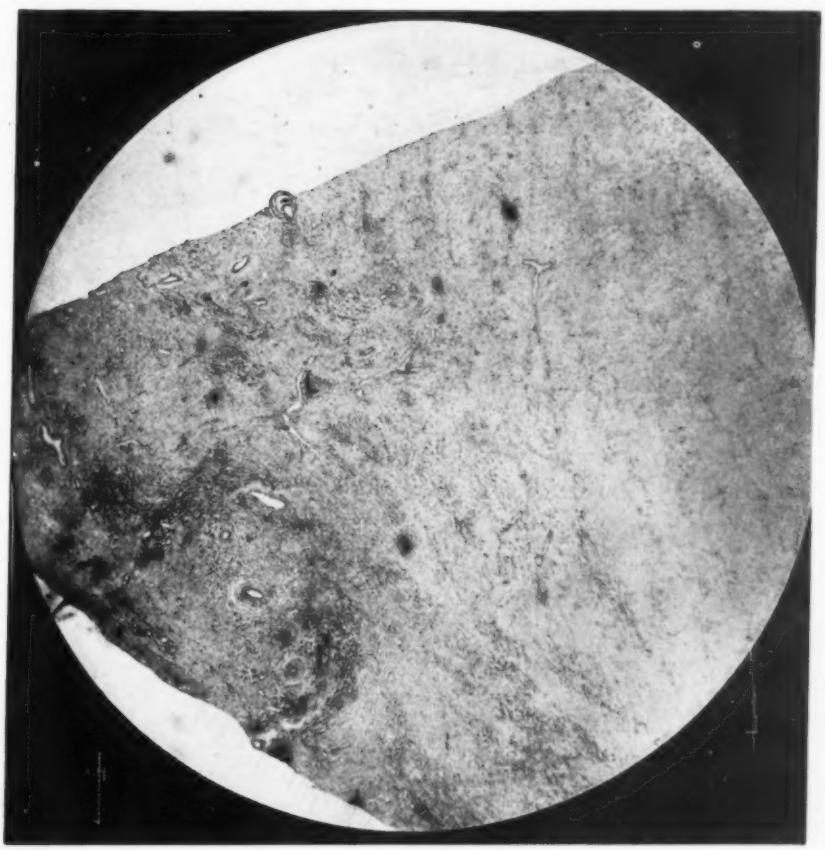

FIG. 2

Section taken from scar tissue mass found in contact with the femur at the first operation.

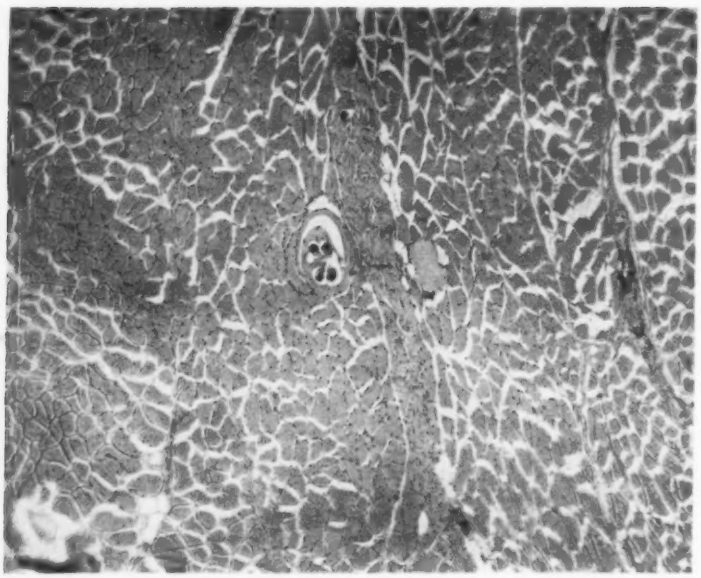

FIG. 3

Section from the deltoid muscle removed Oct. 1, 1927, showing incisted trichinae in muscle.

FIG. 4

Section of bone removed Dec. 29, 1927. No parasites found. Marked increase in compact tissue.

groin. X-rays of the femur taken at this time did not show any increase or decrease in the size of the mass, nor any change in the cortex of the bone. The blood picture was normal with two per cent. eosinophils.

The treatment during this second admission consisted in deep x-ray exposure,—16 minutes. Kv. 200. M.a. 30. F.S.D. 50. Field 10 × 10 cm.

As some doubt had arisen as to the correctness of the diagnosis of sarcoma, Dr. Bennett did an exploratory operation on August 25, 1927, at the Church Home and Infirmary, Baltimore, to determine the nature of the lesion.

An incision was made over the tumor mass in line with the shaft of the femur. The rectus femoris muscle was split to expose the mass which lay over the femur. The collection of fibrous tissue was cut through, and in it several cystic areas were encountered. These areas were drained and cultures were taken. A portion of the fibrous tumor was removed for microscopic sections. The periosteum was then stripped back on the femur and the bone was exposed. The cortex, which was extremely hard, was cut through, exposing a very small medulla. No pus was encountered, so a portion of the cortex about one inch square was removed and the incision was closed. One small iodoform gauze drain was left in the lower end of the incision.

The convalescence was uneventful and the patient was discharged in good condition after a stay of two weeks in the hospital. The incision healed *per primum*.

The cultures taken from the cystic areas and from the bone were negative.

FIG. 5

X-ray of femur taken after last operation. Depression shown where bone was removed. No new bone production.

The pathological report by Dr. Freid, the hospital pathologist, came back as "Infiltrated muscle and scar tissue following x-ray of tumor. Ebonized bone" (Pathological report No. 8200).

There was considerable doubt as to the nature of the scar-tissue mass found in contact with the femur, so a small section was sent to Dr. Ewing in New York. He confirmed the diagnosis as far as the bone specimen was concerned—"Sclerosing osteomyelitis"—; he also found a small cyst in one of the sections which he thought to be trichina (Fig. 2).

To confirm the diagnosis of trichinosis made by Dr. Ewing, the patient was readmitted to the Church Home and Infirmary on October 1, 1927, and a small piece of the left deltoid muscle was removed. The parasites were found in the muscle tissue in moderate numbers, so no doubt remained as to diagnosis (Fig. 3).

To determine whether or not the parasites were in the bone in the area of sclerosing osteomyelitis (The first specimens of bone obtained had been misplaced.), the patient was admitted to the Johns Hopkins Hospital on December 29, 1927, for a biopsy. A piece of bone, about one inch square, from the cortex in the region of the old operation was removed. Very careful study of numerous sections of the specimen removed failed to reveal any of the parasites (Fig. 4). An eosinophilia of five per cent. was found during this admission.

The patient was discharged after a period of one week in the hospital. The incision was closed. No drainage was present.

A recent letter (May 1, 1928) from the patient tells of his present condition. He is having no pain or discomfort in the operative region, his general health has been excellent, and he has been able to return to his work as a coal miner.

Since the first description of sclerosing or non-suppurative osteomyelitis by Garrè in 1893—and from his classical paper the condition is often referred to as Garrè's Disease—a limited number of cases have been reported in the literature. It is our impression that this affection of bone is probably a very much more common disease than these case reports would lead us to believe.

Considerable difference of opinion is found as to the symptomatology. Jones, for instance, writes of high fever, severe pain, night cries, etc., while Henderson feels that the condition is usually subacute or chronic. In the case which we report, the onset was insidious and the course was prolonged.

Practically all authors, however, agree as to the pathology of these cases. Garrè's classification, "The sclerosing type of osteomyelitis cases are those in which there is merely an enlargement and thickening of bone without the occurrence of suppuration and fistula formation", gives the pathological picture found in most instances.

Diagnosis is usually difficult. Sarcoma being, as in our case, very often confused with sclerosing osteomyelitis, an exploratory incision is probably the only means of differentiating between these two diseases. Lues, solid osteitis fibrosa, and Paget's disease usually can be ruled out.

The treatment usually recommended is that of removing a portion of the cortex, or "guttering" of the bone. The condition may return after operation, as Sir Robert Jones stated in discussing the paper by S. Fosdick Jones.

The etiology of this condition still remains obscure. Jones states, "It is the opinion of most observers that trauma cannot be considered as an etiologic factor", though in the case he reports there was a definite history of trauma. Henderson states, "A history of traumatic injury months or years before may be obtained". In his series of thirty cases, seven had a history of trauma. Maxwell Harbin, in the case he reports, gives a history of trauma, as do A. Langer and Cheyne.

Our reason for reporting this interesting case lies in the fact that cystic areas were found in a muscle-fibrous mass in close apposition to the bone. Though no history of trauma was obtained, we feel that the constant pressure and irritation of this mass in close contact with the bone may have acted as a traumatic agent. No trichinae were found in the bone specimens removed, so if the trichinae had anything to do with the bone condition found, it must have been through pressure and irritation of the fibrous mass from the outside.

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News Notes

Dr. Way-Sung New, of Shanghai, China, has changed his address to 236 Seymour Road.

Dr. D. I. Aller has moved his office to Medical Group Building, 1759 Fulton Street, Fresno, California.

The address of Dr. Sydney Klein, formerly of Cleveland, Ohio, has been changed to 1414 Maccabees Building, Detroit, Michigan.

The office of Dr. Arthur W. Allen of Boston has been moved to 264 Beacon Street.

Dr. Lawson Thornton announces the opening of a Fracture and Orthopaedic Clinic at the Piedmont Hospital, Atlanta, Georgia. The name of Dr. Michael Hoke appears as consultant.

Dr. Joel Swanson, who has spent the past year in study in various orthopaedic clinics, is now associated with Dr. C. N. Callander in the Section of Orthopaedic Surgery of the Fargo Clinic, Fargo, North Dakota.

On March 18, 19, and 20, 1929, the Eighth Annual Meeting of the **International Society for Crippled Children** will be held in Minneapolis, Minnesota.

The dates for the International Conference on the Cripple in Geneva, Switzerland, have been set for July 25 to August 4, 1929.

The Annual Assembly of the **Inter-State Post Graduate Medical Association of North America** will be held in Atlanta, Georgia, October 15–19, 1928. An exceedingly attractive program has been arranged. Detailed information may be secured from Edwin Henes, Jr., M.D., Executive Secretary, 445 Milwaukee Street, Milwaukee, Wisconsin.

At the annual meeting of the **British Medical Association** held at Cardiff in July 1928, the Orthopaedic Section met under the presidency of Sir John Lynn-Thomas.

Mr. W. A. Cochrane opened a discussion on low backache and sciatica, and Sir Robert Jones on Volkmann's ischaemic contracture. The discussions were reported in the British Medical Journal for August 11, 1928.

The attention of the *Editor* has been called to two errors in the last issue of the *Journal*: The date of Dr. Spellissy's graduation from Georgetown University, given on page 612, should read 1885. On page 614 the statement is made that Dr. Shaffer was chairman of the committee which secured recognition of Orthopaedic Surgery as a specialty at the Tenth International Medical Congress. The date of this action was 1890.

The Spring Meeting of the **British Orthopaedic Association** was held in Paris on Friday and Saturday, April 27 and 28, 1928. The following program was given by Members of the French Orthopaedic Association:

Friday April 27.

Morning Session —Prof. Ombrédanne, Hôpital des Enfants Malades, 149 rue de Sèveres.
Operations and Clinical Cases.

Afternoon Session—Dr. Mathieu, Hôpital Bretonneau, 2 rue Carpeaux.
Operations and Clinical Cases.
Association Dinner.

Saturday, April 28.

Morning Session —Dr. Mouchet, Hôpital Saint Louis, 14 rue grange aux Belles.
Visit to Musée de l'Hôpital Saint Louis.

Afternoon Session—Reception by Members of the French Orthopaedic Association.

At the thirty-ninth session of the **Washington State Medical Association,** held the last four days of August, in Seattle, the program was largely orthopaedic and urological.

At the request of Dr. R. J. O'Shea, the President, Dr. Murray was instructed to arrange a complete orthopaedic section for the afternoon meeting on August 28. The same was prepared and carried through as follows before the general session:—

Shoes (Lantern Slides). Dr. Joe Brugman, Seattle.
Discussed by Dr. Rich and Dr. Osborne.

The Problem of Ankylosed or Partially Ankylosed Joints. Dr. C. F. Eikenbary, Seattle.
Discussed by Dr. Langworthy and Dr. Rich.

Treatment of Injured Spines (Lantern Slides). Dr. Roger Anderson, Seattle.
Discussed by Dr. Rich and Dr. Wyckoff.

Treatment of Fractures of the Extremities by the Three-piece Plaster-of-Paris Cast. Dr. D. A. Murray, Seattle.
Discussed by Dr. Langworthy and Dr. Trueblood.

Injuries to the Spine in the Cervical Region. Dr. M. Langworthy, Spokane.

On the last day of the meeting the morning session was devoted to a study by Dr. Dean Lewis of Johns Hopkins University upon the subject "The Surgical Lesions of Bone". He discussed in a general way the early diagnosis of osteomyelitis and its early exploratory treatment, maintaining that acute bone symptoms were comparable with symptoms in "acute abdomens", in that both needed early exploratory treatment. With slides he then reviewed enchondroma, myxoma, multiple fibrous osteitis and bone tumors.

The **United States Civil Service Commission** announces the following open competitive examinations:

Senior Medical Officer
Medical Officer
Associate Medical Officer
Assistant Medical Officer
Junior Medical Officer (Interne)
Social Worker (Psychiatric)
Junior Social Worker
Occupational Therapy Aides.

Applications will be rated as received by the United States Civil Service Commission at Washington until December 29. Full information may be obtained from the United States Civil Service Commission at Washington, D. C., or the secretary of the United States Civil Service board of examiners at the post office or customhouse in any city.

At the meeting of the Executive Committee of the **British Orthopaedic Association,** July 12, the following were elected Associate Members of the Association:

Lambert Rogers, Surgical Unit, Cardiff Royal Infirmary, Cardiff.
Bryan Burns, 46 Wimpole Street, London, W. 1.
Andrew Fowler, 9 Rubislaw Terrace, Aberdeen.
Miss Gertrude Hertzfeld, 16 Gt. Stuart Street, Edinburgh.
C. Gordon Irwin, 5 Windsor Terrace, Newcastle-upon-Tyne.

The Conference on Rheumatic Diseases held at Bath, England, on May 10 and 11, 1928, was presided over by the Chief Medical Officer of the Ministry of Health, and was well organized and well attended.

Its object was to consider the nature of the campaign to be organized for the conquest or control of rheumatism. Its net result was to show the appalling ignorance of the medical profession on the causation and treatment of a group of diseases, which annually cost £17,000,000 in loss of wages in Great Britain alone. Papers were read in which many causative factors were suggested and many different treatments advocated. Barren as the Conference was of immediate results, the exchange of views cannot fail to stimulate "new interest in the subject, new ideas for research, and new hope for the future treatment of rheumatism in all its phases".

A brief report of the proceedings was published in the British Medical Journal of May 19, 1928.

Dr. Charles Scudder of Boston opened a discussion on the operative treatment of recent fractures before the **Orthopaedic Section of the Royal Society of Medicine** on April 3, 1928.

Dr. Scudder said that the present-day results of fracture treatment are not good enough; the standard ought to be raised; our aim should be 100 per cent. function in the quickest possible time.

Dr. Scudder pleaded for a more frequent resort to open operation in order to obtain exact anatomical reposition and so accelerate ideal union. Fracture treatment should be in the hands of specialists, possessing certain qualifications. Not all fractures demand operation; the surgeon, therefore, must possess judgment; he should know the possibilities and the limitations of non-operative methods. Furthermore, his technique must be irreproachable and his mechanical skill considerable. He should handle bone as a delicate living structure. He should realize that the aim of treatment is not solely the union of the bony fragments, but the restoration of function to the limb.

Sir Robert Jones said that non-operative methods give a high percentage of results even when exact reposition is not obtained; and moreover non-operative treatment by a surgeon who understands body mechanics is always more successful than operative treatment by a surgeon who neither cares nor knows much about the functions of a limb. For example, in a fracture of the shaft of the femur, overlapping with alignment is better than end-to-end apposition with angulation, even if this be ever so slight. Of many thousands of fractures of both forearm bones, he could remember not more than a dozen on which he had had to operate.

Mr. Hey Groves said that he thought the necessity for complete anatomical reduction was overstressed. He was satisfied if the bone was restored to length and the alignment correct. Operation delays bony union. It requires experience to decide when operation is advisable.

Mr. Fairbank reviewed the commoner fractures and indicated when operative treatment is necessary.

Mr. W. A. Cochrane said that final judgment on the relative merits of different forms of fracture treatment was impossible until accurate records were available; the me.hod of treatment to be adopted in any fracture depended on the capability of the doctor who was to treat it.

DINNER TO SIR ROBERT JONES

On June 28, at the Café Royal, London, a group of surgeons—friends, colleagues and pupils—entertained Sir Robert Jones at dinner. A book, specially written for the occasion and entitled The Robert Jones Birthday Volume, was presented to him. This book comprises a collection of surgical essays. After the loyal toast had been honored, Sir Robert's health was proposed by the chairman, Sir Berkeley Moynihan, the President of the Royal College of Surgeons, in a speech distinguished alike by its brilliance and its affectionate intimacy. Sir Robert replied in a charming and characteristic speech. As an indication of the feelings which prompted this tribute we cannot do better than quote from the preface of the volume Sir Berkeley's actual words:

"This volume, written by a band of brothers, is dedicated with greatest respect and with warmest affection to Sir Robert Jones on the occasion of the seventieth anniversary of his birth.

"The opportunity to pay tribute to our friend, in whom we recognize one of the masters of surgery, was most eagerly welcomed. We felt that it gave us the chance to say openly what has long been in our hearts, in regard to his work for our profession, and in acknowledgement of the inspiration, encouragement, and example he has given to all who have had the high privilege of association with him.

"All those who contribute to this volume are proud to think that the influence of Robert Jones, of his methods, and of his teaching, has inspired them, has found a place in their work to be transmitted by them in due time to their successors. Spirit alone is immortal. In the practice of orthopaedic surgery the spirit of Robert Jones will live forever.

"The story of the triumphs of Robert Jones as prophet, high priest, and practitioner in orthopaedic surgery makes plain the reason for our deep respect. Our affection for him transcends, if it be possible, our gratitude for his professional worthiness. Few men have ever possessed in so radiant a degree the genius for friendship. No one can be long in his company, none can work with him or play with him, without realizing not only the sweet simplicity of his character, but the greatness of his heart. He speaks ill of no man. He seeks and finds good in all things and in all men. He sets an ideal and a standard of action in friendship which all strive to reach when with him. In a long and very intimate friendship I have never heard an unjust criticism, a cruel jibe, or a word of bitter cynicism on his lips. He covers his displeasure or stern disapproval by silence, or a restrained reproof that is often weightier than a torrent of words from others. His personality radiates cheeriness, good temper, and good-will. All men are attracted by him, and in war-time conflicting temperaments found in him something that appeased their differences, assuaged animosities, and encouraged a desire for friendliness. He was then called upon to rule in various places, over colleagues at first unfriendly, openly antagonistic, indifferent to his rule, or incredulous of his practice. We were all amazed at his success in overcoming very real difficulties by gentleness, sympathy, a true understanding of the minds of others, and a tactfulness which in times of crisis was almost magical.

"To Robert Jones, great surgeon, inspiring teacher, loyal colleague, and good friend, we affectionately inscribe this volume."

In addition to Sir Robert's daughter and son-in-law, Mr. and Mrs. Frederick Watson, and his son and daughter-in-law, Mr. and Mrs. Arthur Probyn Jones, the following were present:—Sir Berkeley Moynihan, Sir Harold Stiles, Sir John Lynn-Thomas, Mr. E. Muirhead Little, Prof. Murk Jansen, Mr. A. B. Mitchell, Dr. Thurston Holland, Sir William de Courcy Wheeler, Mr. E. Laming Evans, Mr. H. A. T. Fairbank, Mr. E. W. Hey Groves, Mr. R. C. Elmslie, Mr. A. S. Blundell Bankart, Mr. W. Rowley Bristow, Mr. Naughton Dunn, Mr. G. R. Girdlestone, Mr. Harry Platt, Mr. D. McCrae Aitken, Mr. W. H. Trethowan, Mr. T. P. McMurray.

A Study Trip to European Clinics

Dr. Arthur Steindler of Iowa City, Iowa, accompanied by Dr. Robert E. Schrock of Omaha, Nebraska, recently returned from an extended study trip in Europe. A letter to the *Editor* tells in detail of many of his observations in various European Clinics and, because of its unusual character, a summary of it is presented herewith, that it may be shared with the readers of the *Journal*. The report of such a visit to the principal orthopaedic centers in Europe is of special value to any who may be able to plan similar study trips. Dr. Steindler is a member of the Advisory Editorial Staff, and is peculiarly fitted to interpret to American readers conditions in European Clinics.

—*Editor.*

Dr. Steindler states as the purpose of his extended trip the gathering of useful information on perplexing problems which distrub every orthopaedic surgeon. His hope, not for the solution of such difficulties, but for the acquiring of new and different points of view, was satisfactorily fulfilled, making the trip well worth while.

In Paris, Dr. Steindler visited the clinic of Prof. Ombrédanne where the material is varied, though not exclusively orthopaedic. Osteomyelitis of the spine was the subject of the discussion the day Dr. Steindler spent with him. At the Hospital St. Louis Dr. Mouchet had a large and well conducted out-patient department, treating many rachitic deformities and congenital conditions. Dr. Calot, at the Quai d'Orsay, discussed his theory of subluxation of the hip and its bearing upon the causation of Calvé's disease, coxa vara, and osteo-arthritis. He was also keenly interested in the use of modifying fluids, *e.g.*, resorcin and camphor-napthol glycerin plus iodin and potassium iodide.

In Rome at the Policlinico where Prof. Dalla Vedova is in charge, there are many traumatic cases, as it is the general hospital of the city. The professor has a good clinical and pathological equipment with massage and physiotherapy. The material here was quite rich in congenital dislocations of the hip and club-foot, but there were few tuberculous lesions. A number of osteotomies for hip deformities were shown in which guide nails were used. A complete Zander outfit was a part of their equipment.

From Rome the itinerary led to Florence where the Italian Congress of Radiology was in session and was discussing the osteoses and osteodystrophies. Achondroplasia and osteogenesis imperfecta were also considered in differentiation from rickets, Barlow's disease, congenital syphilis and the juvenile epiphyseal dystrophies,—*e.g.*, Calvé's, Koehler's, Freiberg's, Osgood's, and Scheuermann's diseases and the dysfunction of the hypophyses and the dysostoses cleidocranialis. Prof. Allesandro Bianchini presented a discussion of the osteodystrophies of the adult, especially the differentiation of osteomalacia, rachitis tarda, and the metaplasias, such as osteitis fibrosa of von Recklinghausen and osteitis deformans of Paget. In addition a long list of bone tumors, echinococcus cysts, luetic lesions and osteoporoses were shown, displaying an intimate knowledge of pathology. Prof. Putti exhibited and described cases of platyspondylia with flattening of vertebral bodies and wedge formation.

In Bologna, at Prof. Putt's clinic, the Istituto Rizzoli, improvements in equipment were in evidence, making this the most complete orthopaedic institution in existence. A complete library of orthopaedic literature, a fine pathological museum and Prof. Putti's private collection of old instruments, dating back to the fourteenth century, together with old books to gladden the heart of a connoisseur add to the completeness of the clinic. A full Zander outfit and equipment for mechanotherapy, as well as electric and thermal treatments are provided. A number of operations were witnessed, covering a variety of conditions. The shops of the Istituto have a splendid collection of artificial limbs.

Prof. Galeazzi's Clinic at Milan, Pio Istituto dei Rachitici, was next visited. His method of application of plaster jackets in the treatment of scoliosis was shown. The cast treatment lasts from eighteen months to three years and jackets are changed every

three months. The essential feature of the whole treatment is the preliminary limbering up by prolonged mechanotherapy. Cases illustrating the completeness of the correction and its permanency after removal of the jackets were exhibited. Four hundred and fifty patients with congenital dislocation of the hip had been operated on here in one year and ten or twelve cases were often done in one morning.

In Brussels the chief orthopaedic clinic is in the Bruggeman Hospital, the principal teaching hospital of the University of Brussels. It is conducted by Dr. Danis and Dr. Loicq. Here, as in France, the specialty is not strictly separated from general surgery.

Ghent has a well equipped hospital at the University with 700 beds, the surgery being in charge of Dr. Tydgat.

At Cologne, at the Bürgerspital, Dr. Cramer has the orthopaedic service with 150 beds. A great many osteotomies upon rachitic deformities were performed. Scoliosis was being treated by greater attention to baking, massage, and Bier's hyperaemia than by Zander methods.

In Heidelberg, under Prof. Baeyer, there are 250 beds with an addition being made at the present time. About twenty per cent. of the cases were tuberculous, being treated conservatively. Congenital dislocations of the hip were also being handled conservatively. The Quengel method of Mommson seemed to be the favorite in the management of spastic contractures. Dr. Baeyer is perhaps the foremost kinesiologist in Germany and his work and that of Prof. Weizsacker, who is head of the Department of Neurology at the University, should be better known to American orthopaedic surgeons because of their researches upon the physiology of motion.

In Munich at the University Polyclinic, Prof. Lange is in charge. One of the most interesting things seen here was a demonstration of the Schede-Habermann principle of prosthesis. In the Munich Orthopaedic Clinic, Prof. Lange has 250 beds in the hospital and associated with it is a school and a training school. There is also a museum and a research laboratory provided by the Krause Foundation. Many interesting operative cases and results were shown covering the use of silk tendons for long-range transplantations; the use of Krupp steel wire in anchoring tuberculous spines, angular osteotomies in coxa vara, and arthrodeses in various localities were illustrated. Other interesting work was upon the "myogeloses" and Dr. Pitzen's use of parchment paper for ensheathing tendons. Lange's scoliosis work is also thorough and extensive. At the Red Cross Hospital, Prof. George Hohmann is doing work well worth seeing. He has operated on several hundred hallux valgus cases by a method of his own.

In Berlin, The Oskar Helnesheim is a new institute for cripples. There are accommodations for 300 patients and seventy apprentices. Some very interesting work is being done here. It is chiefly distinguished, however, as the center for the excellent organization which controls the work for cripples throughout Germany. There are seventy-eight of these institutes for cripples with a total of 10,877 beds. Forty-eight of these institutes have provision for rehabilitation training in which seventy-one different occupations are being taught.

At Dr. Max Bohm's private clinic there was exhibited interesting research work on genu varum and valgum in relation to epiphyseal growths and also upon the ossification of the os calcis in cases of club-foot. Dr. Bohm is also organizer of the museum of pros.heses found in the National Museum of Labor, where over 1000 types of prosthesis for the upper and lower extremities are displayed. Dr. Hermann Gocht is in charge of the University Polyclinic. Cases of Volkmann's contracture and claw-foot were operated on.

In Dresden, at the private clinic of Dr. Alfred Schanz, was seen one of the largest of the private orthopaedic clinics in Europe. An interesting operation for the absence of elbow flexors in a case of congenital contracture of both extremities, devised by Dr. Schanz, was demonstrated. Scoliosis, spina bifida, arthroplasty of the hip and numerous osteotomies were also shown. Metal insoles were extensively used here in his out-patient clinic in the treatment of static foot conditions. The Red Cross maintains here an

institution for the treatment of Pott's disease only. There are sixty beds, ten of which are reserved for adult women; the remainder for children. They are all treated alike, by recumbency, with sheet-wadding crosses glued to the kyphos. Recumbency averages two years. Results have been remarkable. Dr. Julius Finck, who is in charge, treats his tuberculous hips with apparatus, allowing deformity to develop which he later corrects by osteotomy.

Prof. Springer's clinic, at the German Children's Hospital in Prague, is undergoing modernization so far as plant and equipment are concerned. He showed his multiple disc operation for correction of deformity in rickets and at the same time overcoming shortening.

In Vienna, Dr. Julius Hass has succeeded Dr. Lorenz at the University Clinic of the Vienna General Hospital. Some of the best results of arthroplasty of the knee were seen here that the writer has ever witnessed. A large number and a great variety of cases were exhibited.

Prof. Hans Spitzy has 400 beds at his disposal at the Orthopaedic Hospital, one of the largest orthopaedic institutes on the Continent. Tendon transplantations and a plastic operation on a case of syndactylism were the most interesting operations shown.

At the Workingmen's Accident Hospital, presided over by Primarius Boehle, the cases are almost wholly fractures. There are about 100 beds. It is here that local anaesthesia in the treatment of fractures is largely used. Ice tongs, or as called there, "Schmerz clamps", are very commonly employed under plaster and removed at the first change of casts. Early ambulatory use is the rule. Unna's zinc-glue bandage is used in sprains and fractures about the wrist and of the radius. The Hospital has been open only three years. During its third year there were 3000 cases treated in the wards.

At Bratislava the Czecho Slovakian Government has established the Kommensky University, the orthopaedic clinic of which is in charge of Prof. Chlumsky. He has a fine equipment with 120 beds at his service and about 2000 new out-patients were treated last year. He was doing the bifurcation operation of Lorenz-Bayer for coxa vara, the excochleation method of Ogston in club-foot and the oblique osteotomy of the metatarsals for hallux valgus. Hydrotherapy was extensively used in combination with sun baths and mechanotherapy in arthritis. Mirion, cadmium, and a cartilage extract called "sanarthrid" were being given, with claims for much benefit, in the treatment of arthritics.

At Graz, Prof. Witte has 185 beds in The Accident Hospital, well equipped for traumatic surgery. The majority of cases were fractures of the lower extremity, many of which were compound. The bloodless treatment of os calcis fractures and arthroplasties of the hip and knee were among the most interesting shown. It is a teaching center for the 600 students enrolled at the University. Not much tuberculosis was seen here as most of this work was carried on at the nearby Convalescent Home at Stolzalpe which has 150 beds. At the Children's Hospital, Prof. Philip Erlacher has about thirty beds where scoliosis and tuberculous bone lesions were being effectively treated, the latter chiefly by recumbency and heliotherapy. Scoliosis was handled on an ingeniously devised frame in which the new application of compensation principles was well carried out.

International relations between the orthopaedic societies are being reestablished. As between Austria and Germany and Great Britain there is no difference in the present and the pre-war conditions. Italian and German relations were restored when Prof. Galeazzi was recognized by putting his name on the program at Nuerenberg in 1927, upon the assurance of reciprocity, which has been carried out by the Italian Orthopaedic Society. Franco-German relations were restored in 1927 when a German member of the German Orthopaedic Society was admitted to membership in the French Society, followed by the readmission of a French member to the German Society in February 1928.

HERMAN LEROY VON LACKUM

H. LeRoy von Lackum, attending surgeon of the New York Orthopaedic Dispensary and Hospital and Assistant Professor of Orthopaedic Surgery at the College of Physicians and Surgeons, Columbia University, was instantly killed on June 30 at Pine Camp, N. Y., while piloting a plane from Miller Field, Staten Island, to Pine Camp, N. Y., to take part in the annual training period of the Squadron. Dr. von Lackum, who was an enthusiastic aviator, had been a member of the Observation Squadron of the Twenty-seventh Division, New York National Guard, for four years. He recently resigned his commission as captain in the Medical Corps, and as surgeon of the Squadron, and was appointed lieutenant in the Air Service.

Although only in his thirty-seventh year, Dr. von Lackum had made a brilliant career and was regarded by his associates as a predominant figure in orthopaedic surgery. His greatness of character and many fine qualities endeared him to all those with whom he came into contact, and his loss is a great sorrow to his many friends throughout the country. He was graduated from the University of Iowa with the degree of B.S. in 1913 and M.D. in 1915. While in college he was a noted athlete and played on the football and baseball teams, and was captain of the latter. After spending two years on the house staff of the University Hospital at Iowa City he became an interne at the New York Orthopaedic Dispensary and Hospital, where he served continuously until the time of his death, having been attending surgeon since January 1923.

His work as a surgeon was characterized by unusual skill and by great courage and invention. His most recent development was that of the removal of a vertebral body in certain cases of scoliosis, which he was ready to publish. In addition to teaching Orthopaedics at the College of Physicians and Surgeons, he was for years a member of the Department of Anatomy and made some notable investigations of the lumbosacral region. He also wrote about the surgical anatomy of the knee joint. Other topics on which he had published papers were joint tuberculosis, subastragaloid arthrodesis, and transplantation of the toe extensors.

Possessed of a magnificent physique and having a great joy in living, his activities were many. He was prominent in many sports, and was well known as an amateur baseball player. His greatest pleasure, aside from his profession, was in flying. During the World War he served as a lieutenant in the Medical Corps. He was a member of the Robert Jones Orthopaedic Club, a fellow of the New York Academy of Medicine, and a member of the University and New York Athletic Clubs. His father, Dr. H. J. von Lackum of Dysart, Iowa, and two brothers, Dr. Harry von Lackum of Rochester, Minn., and Dr. J. K. von Lackum of Cedar Rapids, Iowa, are physicians. He is also survived by his mother and two sisters.

Current Literature

FOLKLORE OF THE TEETH. By Leo Kanner. New York, The MacMillan Company, 1928.

This entertaining study of the superstitions which have gathered about the teeth and their function in the human economy is a distinct contribution to folklore. All the organs of the body have been centers about which symbolism and its expression, folklore, has gathered, but about none is this more true than of the dental apparatus. Starting with the eruption of the teeth, superstitions arose. If the child was born with an erupted tooth, in some localities it was regarded as of good omen; in others the contrary was true; whereas in some parts of Africa such a child would be put out of the way. The importance of cleanliness within the mouth was early enjoined among the Arabs as a divine law, and for this purpose tooth brushes and tooth picks can be shown to be of very ancient origin. Toothache has always been regarded with great dread and much fanciful belief in regard to its causation has found its way into folklore. About the same time that it was claimed that there were worms in the teeth which caused toothache, the first micro-organisms were discovered in the tartar. As might be supposed, the number of toothache cures is limitless,—including plants, animals, chemicals, written and spoken charms, and the relics of St. Appolonia, the Patroness of Toothache. One of the methods of cure was by transference,—*e.g.*, to a tree or a rock or some other inanimate object. Dental surgery furnished a splendid opportunity for the exploitation of many fanciful ideas. The custom of deforming the teeth by pointing or notching, coloring, inlaying, and artificial prognathism is very common with savage races even to-day. Many primitive people use the teeth to manufacture cutting instruments and tools as well as for ornaments, jewelry, and various sorts of charms and drugs, relics and souvenirs.

The book represents a vast amount of research and to it is appended an extensive bibliography.

CORRECTIVE PHYSICAL EDUCATION FOR GROUPS. By C. L. Lowman, Claire Colestock, and Hazel Cooper. New York, A. S. Barnes and Co., 1928.

The recent publication of a book entitled "Corrective Physical Education for Groups", prepared by Dr. Charles LeRoy Lowman and his associates, seems to represent a very valuable contribution to that which has to do with physical education in general, as well as that which has to do with the physiologic reconstruction of the body in controlling so many of the chronic diseases now commonly handled so unsatisfactorily by the medical profession. Most that has been written on the subject of physical education has dealt chiefly with the presentation of systems of exercises leading to the delicate coordination of the individual muscle groups. Of late most writers have considered in their discussions the question of the right use of the body, correct posture, or similar terms being used to indicate this. However, so little emphasis has been put upon this question and the exercises have been given so commonly without regard to it, that many times very little good has been done by such systems, and, without question, at times distinct harm, in that the fatigue, which is part of the imperfect control of the muscles, is increased by the added work.

In the book which has been presented by Dr. Lowman and his associates, the emphasis is put upon the correct balance of the body; so that whatever the use of the muscle, it is performed in its correct physiologic position. If properly balanced, the extensors and flexors, the muscles of one side or the other should work in balance; so that very light exercise results in the stimulation of each of the muscle groups that would, naturally, be opposed. Once this correct balance of the body is obtained, then any

system of exercise that leads to better and better control of the individual muscle is, of course, to be encouraged; but to attempt to obtain delicate control of the muscles without first securing the proper muscle balance is entirely illogical and, without question' at times harmful.

One reason why there are so many systems of exercise, none of which, apparently, are entirely satisfactory is, it seems to the reviewer, that the fundamental need, which is of the body correctly balanced, is missed by most of those who are responsible for such systems.

This work of Dr. Lowman and his associates seems to leave very little to be desired as to its fundamentals, and once those are accepted, there is no limit to the amount of work that can be performed. Physical education faced in this way will demand the respect of the world, while physical education, as much of it is being presented today, is already being questioned by many, because the results are so unsatisfactory.

PRAKTISCHE ORTHOPÄDIE. By A. Schanz. Berlin, Julius Springer, 1928.

Compared with the usual textbooks Schanz's book is incomplete, and the reader will miss material in many respects; but he will be fully compensated by the great enthusiasm with which that famous master in Orthopaedics fills his pages and the heart of the reader alike. It is the peculiar personal note that gives its greatest value to this book.

There are many true sentences and observations which are obvious to every orthopaedic surgeon with some experience,—*e.g.* when he writes about the borderlines and when he states that the experienced eye of the orthopaedic surgeon or of any surgeon or physician who has learned to see and to think along orthopaedic lines, will detect orthopaedic problems in many cases and under many conditions where the untrained eye cannot see anything of interest.

He remarks that the frequent combination of general and orthopaedic surgery usually leads in the end either to a total surgeon or to a total orthopaedist, and in the book of an orthopaedist who excels in the surgical part of his line and is a renowned master in the surgical art, such an observation is of particular value. Moreover, he says that the long duration of the treatment binds surgeon and patient together in a way peculiar to the orthopaedic work, and the surgeon will learn to understand the troubles and wishes and the peculiar psychological needs of his patients. Thus, he goes on, "Here is for the orthopaedist the highest art and the secret that makes the real orthopaedic surgeon love his work so dearly".

In most chapters the book shows rich casuistics and covers many borderline fields. The reader will find the author to be not only an excellent surgeon and mechanic, but also a good physician, pediatrician, and natural scientist. Everywhere a large practical experience is noted. The essential point is often brought out with a few precise remarks. He rarely stops to discuss the opinion and methods of others (perhaps he mentions or briefly describes them), but generally he gives just his own opinion,—the result of a large experience, logical thinking, exact observation, and expert technique.

Of particular interest and special value are those chapters where he discusses the weak spine and the weak foot and their strain or, as he calls it, the "insufficientia dorsi and pedis". Those ideas were much discussed and sometimes belittled in the German literature, but they are only too true. The careful reader will observe that Schanz's ideas are practically identical with those of Goldthwait and his pupils in regard to the weak back, the faulty posture, and the postural strain; and with those of Whitman in regard to the weak foot. The terms are different, but the meaning is the same and no orthopaedic surgeon with an open eye can pass those cases without being convinced of the deep truth in Schanz's observations.

In an age where exercise, gymnastics, and sport are in such high repute, the admonitions of Schanz, in discussing the exercises for treatment of scoliosis, are of particular value; and every orthopaedic surgeon will agree with him in his advice to handle such

cases with the greatest care and delicacy, as the usefulness of exercise treatment in scoliosis may often be questioned, whereas the danger of harm may be great.

The book is divided, a small section dealing with general orthopaedics and the greater part of the book with special orthopaedics. In the latter part he discusses, at first, those diseases which lead to orthopaedic affections, such as rickets, tuberculosis, arthritis, and paralyses. Then he covers the whole body from the head to the foot, and closes with an excellent chapter on amputations and exarticulations and prostheses.

Schanz's book can be highly recommended, both to the orthopaedic surgeon and to the general practitioner. The former will find an interesting field for discussion and thinking, while the latter will find help in detecting orthopaedic conditions in his patients.

ORTHOPEDIC SURGERY FOR NURSES. By Philip Lewin. Philadelphia, W. B. Saunders Co., 1928. $3.25.

"If the other nurses' orthopaedic books are primers, this is a high school textbook." This is the valuation placed on Lewin's book by a nurse with much capable experience in directing an orthopaedic hospital. Within its 350 pages this book contains a large mass of facts, well arranged and interestingly presented. Included in these are many points of particular interest to nurses. One might criticize the undue space awarded the author's "hobbies",—such as the three pages on apophysitis of the os calcis and the three pages on the Lewin modification of the Hibbs operation, but in general this does not crowd out any material essential to a nurses' textbook. A few obsoletisms such as the use of "spirochaeta pallida" for "treponema pallidum" and the suggestion that scurvy is infectious in origin are noted, but on the whole, this volume is a very comprehensive "Orthopedic Surgery for Nurses".

The *Journal* wishes to acknowledge the receipt of the following books sent to the Editorial Department:

A Text-Book of Fractures and Dislocations. By Kellog Speed. Ed. 2, Philadelphia, Lea & Febiger, 1928.

Proceedings of a Conference on Rheumatic Diseases, held at Bath, England, May 10 and 11, 1928. Bath, The Hot Mineral Baths Committee of the Bath City Council.

The Medical Schools, The University of Chicago, Announcements, Chicago, The University of Chicago Press, 1928.

Clinica Gil, Medellin, Colombia, Vol. V, Nos. 25 to 27, February to June 1928.

Bullettino E Atti della Reale Accademia Medica di Roma, Rome, Vol. LIV, Nos. 5 and 6, May and June 1928.

Boletin de la Sociedad de Cirugia de Chile. Santiago, Chile, Vol. VI, Nos. 3, 4 and 5, April 25, May 9, and May 23, 1928.

CONGENITAL ABSENCE OF THE FEMUR, PATELLA, TARSAL SCAPHOID, AND ISCHIUM ASSOCIATED WITH OTHER ABNORMALITIES. A. R. Shands, Jr. *Am. J. Roentgenol.*, XIX, 531, June 1928.

This is a very interesting case of congenital anomaly and is extremely well described and illustrated with radiographs. The review of the literature is also given. The author finds that the femur is the fifth most common bone affected in congenital abnormalities. The fibula is first, tibia second, the ulna third, and the radius fourth.—*Edward S. Hatch, M.D., New Orleans, La.*

THE ROENTGENOLOGIC DEMONSTRATION OF NON-UNION IN THE FEMORAL NECK. P. M. Hickey. *Am. J. Roentgenol.*, XX, 14, July 1928.

One of our best known roentgenologists has written this paper which will appeal to all surgeons who are doing bone and joint work. This work, as the author says, is not designed to check up on the result of early treatment of intercapsular fractures of the hip, but on the result of completed treatment. "It is helpful in deciding whether operative treatment is necessary, after the usual classic methods of treatment have been tried

for an appropriate length of time." Three films are taken: one with the hip and femur in the usual position, one of the femur in extreme abduction with the pelvis immobilized, and one with the femur in extreme adduction with the pelvis immobilized. If the head and neck retain the same relative positions in the different radiographs, it is evident that union is firm. If not, it is evident that union has not taken place.—*Edward S. Hatch, M.D., New Orleans, La.*

BONE ATROPHY OF SUDECK. G. Segre. *Ann. Italiana di Chir.*, VI, 555, June 30, 1927.

Based on the observation of two cases of bone atrophy of the wrist following injury, the author gives a critical and bibliographic review of the condition. He divides the work into chapters considering the pathogenesis, the etiology, the roentgenologic picture, the diagnosis, the pathologic anatomy, the prognosis and the treatment, making a critical analysis in each instance.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

THE COMPLEMENT FIXATION REACTION IN BONE AND JOINT TUBERCULOSIS. G. Jemma. *Ann. Italiana di chir.*, VI, 576, June 30, 1927.

The author has done the complement fixation test on fifty-five children affected by osteo-articular tuberculosis. The antigen used was that of Wassermann and that of Besreka. Simultaneously with the complement fixation he did the Wassermann test for syphillis and the cutaneous tuberculin test. The author has taken as positive only those tests in which their evident clearness offered no possibility for discussion.

He concludes as follows: The reaction of complement fixation for tuberculosis done with the antigen of Besreka upon the serum of fifty-five children, varying in age from two to thirteen years, affected by various surgical forms, presumably of specific nature, resulted positive in seventy-six and six-tenths per cent. and negative in twenty-five and four-tenths per cent. The reaction with the antigen of Wassermann was positive in sixty-six per cent. and negative in thirty-four per cent. The syphilitic reaction with antigen done eleven times resulted in positives seven times and in these the reaction was positive with the tubercular antigen. The reaction done five times upon the articular exudate, using the antigen of Wassermann, was positive four times and, using the antigen of Besreka, was positive three times. It confirms the results obtained with the reaction upon the blood and sometimes may develop a positive when the blood gives a negative. If the tests upon the exudate and upon the serum result positively contemporaneously, the test acquires a greater value.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

CONTRIBUTION TO THE STUDY OF NON-TRAUMATIC MUSCLE OSSIFICATION. A. Violato. *Ann. Italiana di Chir.*, VI, 697, July 30, 1927.

The author reports a case observed in a woman of forty. The bone particle was localized at the thenar eminence of the right hand. The ossification could not be imputed to trauma. The small bone particle was removed surgically and studied histologically. The anatomical study excluded neoplasm and caused the author to consider a new formation of bone tissue in an abnormal site, secondary and consecutive to an interstitial process situated in the muscle or in the interstitial connective tissue which has replaced the matrix. Regarding the pathogenesis the author suggests two hypotheses,—either an inflammatory process of very limited area, or a degeneration limited to the nerve terminals of the thenar eminence that has caused an abnormal state of a chemical or degenerative nature, which then gives place to ossification.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R.I.*)

TRAUMATIC OSTEOPOROSIS OF THE CARPAL BONES. Joseph Buchman. *Ann. Surg.*, LXXXVII, 892, June 1928.

This contribution deals with a little known disease entity for which the term Trau-

matic Osteoporosis of the Carpal Bones seems most applicable. It has been previously described under various names, such as Kienboch's disease of the carpal semilunar, and Preiser's disease of the carpal scaphoid. A résumé of the historical facts, anamnesis, clinical, roentgenological, pathogenic, and pathological pictures are given. The author thinks the disease comparable to Kümmell's disease of the spine. He advises conservative treatment in the form of physiotherapy and support for varying periods of time. If symptoms persist, operative removal of offending bones is justified. Seven case reports are added. The scaphoid, semilunar, os magnum, and unciform have been found involved.—*Fred G. Hodgson, M.D., Atlanta, Ga.*

Fracture and Dislocation of the Sternum. Report of Three Cases. Herbert H. Holderman. *Ann. Surg.*, LXXXVIII, 252, Aug. 1928.

This is a rare condition. The ribs usually break first. Direct trauma is the most frequent cause. Blows or compression of chest are most frequent causes. It has been known to occur from muscular action. The most common type is a transverse fracture at the junction of the manubrium with the gladiolus. The prognosis is good, except in the complicated cases. Diagnosis is usually not difficult. The lateral x-ray shows the fracture better than the anteroposterior view. Reduction is accomplished by hyperextension of the head and arms over the end of a table. Open operation is justifiable if manipulation fails. Adhesive strapping and rest in bed is the best treatment. Three cases are reported.—*Fred G. Hodgson, M.D., Atlanta, Ga.*

Treatment of Fractures Involving the Ankle Joint. Fraser B. Gurd. *Ann. Surg.*, LXXXVIII, 260, Aug. 1928.

The causes and classification of ankle fractures are discussed. Early reduction is important. Manipulation under an anaesthetic is best. Following reduction, the limb is placed in a pillow splint. The details of application are described. The foot is held at right angles and in adduction or abduction as required. The pillow is held snugly in place by safety pins. X-rays are made with the limb in the pillow splint. The pillow splint is left on until it is considered safe to apply plaster. The cast is left on ten days. Then physiotherapy is started. After three to six days a snug-fitting walking plaster is applied over stockinette and a felt heel strapped on. Walking with or without crutches is commenced. Many patients return to work within a week or two of being injured. The end results are better and the period of disability shortened. The patient should not be permitted to walk without plaster for eight to twelve weeks in the severe cases. A wedge heel is used when shoes are worn.—*Fred G. Hodgson, M.D., Atlanta, Ga.*

A Sign of the Great Toe. A. Lavermicocca. *Arch. di Ortop.*, XLIII, 3, 1927.

With a reserve for further bibliographic study of the particulars of the sign, the author describes what he offers. "If the leg is grasped a little above the malleoli so that the four fingers of the hand rest encircling the posterior surface of the leg and the ring thus formed with the thumb and index finger is constricted, pressing with the index finger onto the Achilles tendon while the foot is relaxed, one observes that the distal phalanx of the great toe flexes, only to return to its original position as soon as the constriction is released." In small children the manipulation is made with greater delicacy. In them, besides, by the method given above, the sign can be produced by compressing the ankle (a little above the os calcis) as in pincers with the thumb on the Achilles tendon and the index finger opposite on the anterior surface of the leg.

The sign of the great toe is positive and is produced constantly and typically in all normal individuals or those in whom the extremity under examination is free from functional disturbance.

The dependence of the sign upon nerve stimulation is excluded by the author by

positive proof in an anatomical specimen and he holds that it is due to a mechanical factor. He reinforces the assertion by exposition of drawings of the region of the flexor proprius hallucis, demonstrating an anatomical detail which he states has never been given in treatises. The inferior portion of the muscle with its tendon remains for a certain distance isolated from every other element, and corresponding to its under surface is an open space. The disposition and direction of the muscle and tendon are diagonal. Thus digital pressure at the given point tightens the tendinous portion of the muscle in question, causing the phenomenon.

The author has never encountered the sign in infantile paralysis where the process involved the flexor longus hallucis (sign of the great toe, negative), an absence confirmed by neurological examination and at operation. That allows, according to the author, giving a practical value, at least in orthopaedics, to this physical sign, in that the absence of the sign indicates that the muscle is completely paralyzed while its slow and weak response (sign of great toe, weak) indicates that the muscle is partly degenerated, as shown also at operation. Further, the sign is intimately associated with the degree of tonicity of the muscle mass, of which it follows the fate,—muscle tone being understood as material elastic tension proper to the muscle fibers.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

Osteochondritis Dissecans. S. Burt Wolbach and Nathaniel Allison. *Arch. Surg.*, XVI, 1176, June 1928.

After a concise review of the theories offered for the production of loose bodies in osteochondritis dissecans, there is presented an instructive report of a case of diabetes mellitus in which at autopsy there was found a loose body in the knee. Following careful gross and microscopic studies, the authors arrive at the conclusion that the separation of the fragment was due to mechanical pressure on a portion of the articular cartilage bridging a cyst.—*I. Wm. Nachlas, M.D., Baltimore, Md.*

Fractures of the Upper End of the Femur. J. J. M. Shaw. *British J. Surg.*, XVI, 120, July 1928.

Fractures were produced experimentally on the cadavers of subjects over sixty-five years of age. The following conclusions were drawn:

1. Fractures of the narrow part of the neck are due to an axial twist of the femur, an indirect violence.
2. Fractures of the broad part of the neck, and intertrochanteric fractures, are due to direct violence over the trochanter, or to outward leverage of the shaft when head and trochanter are fixed.
3. Fractures of the acetabulum are due to force transmitted directly along the capito-collar axis, by violence applied immediately below the great trochanter.
4. Fractures of the pelvic girdle may be produced by the application of slowly increasing, powerful pressure over the trochanters.

Direct Skeletal Traction in the Treatment of Fractures. E. W. Hey Groves. *British J. Surg.*, XVI, 149, July 1928.

The writer states that there is no ununited fractured long bone which cannot be corrected to full length and proper axis by skeletal traction. He discusses the use of the transfixion pin, nails driven into the sides of the bone, ice-tongs calipers, horseshoe clamp with screws, os calcis stirrups, and silk and wire loops. He believes that the transfixion pin is the most satisfactory.

It is always necessary to use a general anaesthetic in applying these pins, whether through the lower end of the femoral shaft above the condyles, in the tibia, below the tibial tubercle, or through the olecranon in fractures of the humerus. The technique of the application is given in full.

When the lateral displacement requires reduction by open operation, and the bones cannot be made to interlock, he partially transfixes the fragments by metal bradawls. These are left in place while the plaster is applied and are incorporated in the plaster. He claims that union is faster than by the use of plates and screws.

ISOLATED CONTUSIONS OF BONES. (Experimental research.) G. Toschi. *Chir. d. org. di movimento*, XII, 41, Jan. 1928.

The author, by means of a bruising apparatus devised by him and with which the violence of the trauma can be fixed accurately, has produced pure contusions of bone (*i.e.*, not associated with fractures, infractions, fissures or the detachment of even minute fragments) in the middle third on the antero-internal surface of the right tibia of rabbits of the same age and same state of nutrition. In a series of experiments, studying at varying intervals the objective signs and the macroscopic and microscopic alterations in the contused right tibia with the non-traumatized left tibia, the author reveals the various clinical factors (pain, redness, ecchymosis, tumefaction of soft parts and bone, functional disturbances) and the anatomopathological factors (subperiosteal bone changes, etc.) represented by extravasated blood, by oedema, by proliferation and multiplication of formative cells of bone and of fibrous connective tissue even to the formation of haversian architecture, that calcified reproduces exostoses and hyperostoses, and that from the anatomopathologic point of view would be defined as circumscribed traumatic osteoperiostoses.

The experimental researches, illustrated with figures of the various states of the evolution of bone contusions, are followed by considerations regarding the process of subperiosteal ossification and by conclusions which have a certain practical value.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

A RARE VARIETY OF ISCHIO-ACETABULAR FRACTURE. F. Leinati. *Chir. d. org. d. movimento*, XII, 64, Jan. 1928.

Complete fracture of the ischium, or fracture of Walther, has been hitherto only produced experimentally, being effected on the skeleton by direct trauma. The observation reported by the author is the first described as occurring clinically. It occurred in an obese woman of sixty-three in whom, due to an automobile accident, there was caused by indirect mechanism the typical lesion of the ischium described by Walther and accompanied by a partial mesial luxation of the femoral head. The manual reduction of the deformity, done immediately by a manoeuver devised by Professor Morone to whom the case belonged and inspired by Kocher's method of reduction of dislocation of the shoulder, allowed a complete restoration both anatomical and functional. As a late complication there developed a traumatic arthritis of the hip.

The study of the case is completed by that of another clinical observation of a partial fracture of the ischium. The conclusions which can be deduced are the following:

1. The fracture of Walther which has had hitherto only an experimental interest acquires with the observation of Morone the value of an easily demonstrable clinical entity.
2. It may be occasioned by indirect trauma as well as by direct trauma such as in the experiments of Walther.
3. The fracture of Walther by indirect trauma presents two very important complications because they may be factors in the diagnosis,—mesial subluxation of the femoral head and contusion of the sciatic nerve.
4. The fracture of Walther with an immediate diagnosis and an immediate application of rational treatment is susceptible of anatomical and functional cure.

—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

OBSERVATIONS ON TRAUMATIC OSSIFICATION OF THE EPICONDYLES AND PARACONDYLES OF THE FEMUR. A. Pellegrini. *Chir. d. org. di movimento,* XII, 83, Jan. 1928.

The author recalls a personal case of traumatic ossification of the internal lateral ligament of the knee published in "Clinica Moderna" in 1905. This would be the first case of traumatic ossification of the inner side of the knee, since the report of Stiada was in 1907. The author illustrates seven other cases of traumatic ossification in the region of the internal femoral condyle.

The principal conclusions that can be drawn from the report are the following:

Traumatic ossifications of the inner side of the knee are more frequent than has been believed.

Ordinarily they are observed in men and usually in the middle decades, through industrial accidents and in sports.

The trauma that provokes it is varied, more often it is indirect trauma (distortion in valgus), more rarely direct violence (contusion), sometimes a combination of the two.

The pathology varies; it may be a primary osseous lesion through a small fracture of the internal condyle of the femur or it may be (and this is more frequent) a secondary ossification following a laceration of or tearing off of the internal lateral ligament or sometimes of the adductor muscle.

The radiograph made directly after the injury may be negative since the time necessary for the formation of the ossification has not elapsed, hence it is opportune to repeat. The symptoms are often slight, clinical diagnosis is difficult, and many cases escape diagnosis. Therefore the examination must be careful. With the knees in acute flexion it is easier to reveal by inspection and palpation a tubercle rising on the internal aspect of the injured knee. Radiographic examination is necessary and decisive for the diagnosis. It is necessary to be careful and, in general, not to exclude the lesion without radiographic examination made with all the caution the case requires.

In injured knees which remain long painful, radiographic examination is necessary before considering malingering or traumatic neurosis. Sometimes it is difficult to establish whether the ossification under examination is due to the injury claimed or to a preceding one.

Directly after the trauma, immediate immobilization of the knee is indicated and later mobilization, and this should be slow and gradual. Thermotherapy is very useful. Surgical intervention is indicated only exceptionally. Forcible mobilization and mechanotherapy may prove damaging rather than useful.

The temporary disability is frequently long and there may remain a permanent disability of five to twenty per cent.

Besides pains, limitation of movement, and the impossibility of long standing on the feet, sometimes there remains a certain degree of brittleness and a predisposition to a repetition of similar lesions.

It is necessary to modify somewhat the common conception that distortion of the knee is always a lesion of slight gravity and curable in a few days without sequelae. A certain prudence is advisable in the prognosis of articular and mixed articular thigh injuries.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

ON A FORM OF POLIOMYELITIS WITH PERSISTENT INTENSE PAIN (THE SO CALLED POLYNEURITIC FORM). A. Fucci. *Chir. d. org. di movimento,* XII, 105, Mar. 1928.

The author has had occasion to observe in the Pediatric Clinic of Bologna during the years 1925–1926 four cases of Heinemedin's disease, characterized by the intensity and long persistence of the symptom pain and in two cases by the existence of contractures contrasting with the ordinary conception of the flaccidity of infantile paralysis. These contractures had developed contemporaneously with the pain. After reviewing the various hypotheses regarding the localization of the pain in the sensory paths to explain the origin of the symptoms of sensory irritation in poliomyelitis and having shown the opinion of various authors in regard to it, he holds that the initial pain of the

common forms of infantile paralysis must be distinguished from that of the forms with persistent pain of the neuritic type.

The initial pain of the first is to be attributed either to the irritation of the posterior roots in proportion to the meningeal reaction (which almost always exists in a greater or less degree), or to the irritation of the posterior gray substance, since the inflammatory process is never sharply delimited, as was once believed, to the anterior horns, but always extends, at least at the beginning, more or less into the posterior horns.

The localization of the pain in the persistently painful forms is various, and if the importance of the continuance of the round-cell infiltration around the posterior roots cannot be denied, especially if there were at the onset evident meningeal signs and marked changes in the fluid, one must recognize nevertheless that often the meningeal reaction is slight; so it is very probable, especially in the cases with pain on pressure on the nerve trunks, that there is a neuritis even if no objective alterations of sensibility are present. In the rarer cases, in which circumscribed zones of hyperalgesia exist, it is probable on the other hand that there is a localization of the virus in the intervertebral ganglia and in the Gasserian ganglion.

Passing then to a consideration of the contractures that appeared contemporaneously with the pain in the two cases described, after recalling the various forms of contracture that may be observed in poliomyelitis, the author concludes, suggesting that the state of contracture, developing precociously in the paralytic period of the very painful forms of Heinemedin's disease, is in part a reflex contracture through irritation of the sensory afferent neuron at some point (roots or peripheral fibers) and in part is a conscious stiffening to avoid the provocation of pain.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

KÖHLER'S DISEASE OF THE TARSAL SCAPHOID. K. Speed. *Chir. d. org. di movimento*, XII, 140, Mar. 1928.

The author reports a case of Köhler's disease in a child of six years in which, at the request of the parents, a scaphoidectomy was done, and thus a study made of the histologic alterations.

The clinical picture and the roentgenological appearance showed a typical case of Köhler's disease. The roentgenogram of the bone revealed a lobular structure of the nucleus, of a uniform density, exactly differentiated from the surrounding cartilage.

From the microscopic examination the author would deduce that there was an arrested state of development of the normal ossification, from which there would be left necrotic bone and amorphous calcified areas, with an absence of any inflammatory phenomenon.

The author, after a general review of the clinical picture of Köhler's disease, reports the opinion of various authors. The author believes in a nutritional disturbance due perhaps to trauma or to extravasation of blood. The normal process of ossification was arrested, at least temporarily.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

CONTRIBUTION TO THE STUDY OF OSGOOD-SCHLATTER DISEASE. T. Anardi. *Chir. d. org. di movimento*, XII, 187, Mar. 1928.

The author reports a case of detachment of the anterior tuberosity of the right tibia in a youth of eighteen years. He gives the clinical and roentgenological study of the case as well as the microscopic examination of the fragments removed from the surface of the detached piece in which was revealed an irregular ossification and a notable retardation of the processes of calcification and of formation of osteoid tissue. From the aggregate of the data collected, it seems to the author that he must classify the case reported under the clinical picture known under the name of Osgood-Schlatter disease.

Regarding the pathogenesis of the affection which is still much discussed, the author, on account of the manner in which the lesion is caused, on account of the struc-

tural changes and on account of the roentgenological appearance of the small sella turcica, holds that the disease must be attributed to an endocrine disturbance in general with special regard to those glands that more directly influence skeletal development in man, rather than to a traumatic or inflammatory factor.

The alterations or dysfunctions of these glands may be congenital and consecutive to disease in a majority of the cases of general type, therefore not a universal mechanism, though in most cases an endocrine disturbance.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

A New Plaster Bed. M. Šarčevič. *Chir. d. org. di movimento*, XII, 207, Mar. 1928.

Describes the construction of a plaster bed made with twisted plaster ropes. The position of the spinal column in this bed, according to the author, is better guaranteed since the patient is constrained to rest only upon the points of contact made for that purpose.

The author gives the necessary technique.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

The Tuberculosis of the Hip in a Heliomaritime Institute. A. Mezzari (Trieste). *Chir. d. org. di movimento*, XII, 313, July 1928.

This investigation covers 356 cases of hip disease treated in the Sanatorium Duchessa Elena d'Aosta. The larger portion of the cases were advanced ones, showing already destructive lesions and gross deformity, frequently large abscesses, numerous fistulae and often profound cachexia with degeneration of internal organs.

Frequency. His statistics are in accord with those of the Istituto Rizzoli, in that he places the tuberculosis of the hip in second place among the tuberculoses of the skeleton. In fifty-two and eight-tenths per cent. the left side, in forty-two and two-tenths per cent. the right side, and in three per cent. both sides were the seat of the disease. Fifty-eight per cent. were males and forty-one per cent. females. The greatest frequency was observed in the second three years of life.

Heredity. In forty per cent. of the cases near relatives were afflicted with tuberculous disease; this figure is almost the same as that found in the Istituto Rizzoli. Twenty-four per cent. of the children with tuberculous hip disease had one or more members of the immediate family or the surroundings afflicted with tuberculosis of the lung. Of concomitant tuberculous diseases, he found that thirty-three and five-tenths per cent. of the cases were associated with other tuberculous lesions, of which lymphadenitis, spondylitis, gonitis, pleurisy, and lung tuberculosis were the most frequent.

Trauma. In eighty per cent. of the patients data referable to a preceding trauma existed.

Symptoms. The most constant if not the earliest symptom is the limp; next is the vague, dull or sharp pain, which makes its appearance most frequently in the early stages of the disease, sometimes inguinal, sometimes located at the antero-internal aspect of the thigh, less frequently in the gluteal region, occasionally referred to the inner side of the knee, rarely at the calf. Painless onset of the disease is rather rare and was observed in only four per cent. of the cases.

The knee pain occurred with a frequency of thirty-five per cent. In three per cent. of the cases there was acute onset of the tuberculous hip disease, with marked phenomena of local reaction, and with acute spontaneous and elicited pain. Sudden contractures and rise of temperature were observed.

Limitation of movement. In the type with primary synovial or capsular involvement, there is a complete rigidity due to muscular contracture with position of abduction, flexion, and outward rotation. In the primary extra-articular type the movements of the limb are limited and especially such movements as distend the points of attachment of ligaments or muscles in the proximity of the tuberculous focus. It is also the intensity

of the local reaction of the tuberculous focus which tends to limit motion of the hip. In fact, among the eleven cases with acute onset and very intense pain, the suppression of mobility was always absolute. The statistics also showed that in the initial period the motion is restricted, first in direction of extension, then abduction, and internal rotation.

Abscesses and sinuses. Among the 356 cases, abscesses were found in fifty-one per cent. and sinus formation in tuberculous hip was observed in thirty-four and two-tenths per cent. Amyloid degeneration of the viscera occurs in cases of mixed infection. Of the twenty-nine deaths in this series thirteen succumbed to the cachexia produced by amyloid degeneration in mixed infection. In one and nine-tenths per cent. of the cases with sinuses, there was persistent oedema of the entire limb produced by compression of large vessels by old fistulous tracts. The enlargement of the glands in the iliac fossa, a symptom to which Lannelongue especially calls attention, was observed eleven times, or in three and one-tenth per cent., and is always dependent upon localization of the tuberculous focus in the floor of the acetabulum.

The local treatment. In cases of faulty position the author carries out careful attempts at correction by casts, with or without anaesthesia. This was done twenty-three times without complications arising. In extra-articular localization, or in cases of only mild destruction of the bone, fixation in plaster cast was carried out as a routine treatment. He has experimented with various fixation beds and splints, but in his practice a well modelled plaster-of-Paris cast has proved the most practical and effective means of controlling the disease. His preference for plaster-of-Paris fixation is the more remarkable as the author is associated with one of the largest institutes for heliotherapy. He believes that the value of the orthopaedic treatment even in these days of heliotherapy should not be measured by the number of cases of hip disease healing with mobility, but rather by the number of cases healed in good position. He can see a certain beneficial effect in the local application of the sun rays, especially as far as the soft parts are concerned, but this effect is undoubtedly less important than the advantage offered by fixation in plaster-of-Paris casts. He believes that no treatment for tuberculosis of the hip will equal that of complete immobilization and that the best means of accomplishing this is a well made plaster-of-Paris cast. In convalescent cases the plaster is replaced by a celluloid brace which is also worn at night. The decision as to the stage of repair depends largely on the x-ray evidence.

Treatment of abscesses. Small abscesses within the capsule or pericapsule abscesses were always respected and allowed to retrogress spontaneously without interference. Gross abscesses with progressive course were punctured in order to avoid sinus formation. A simple mechanical evacuation of the abscess by puncture was carried out as a rule. Injections of modifying fluids as recommended by Calot gave no better results than simple evacuation, although with napthol-camphor the abscess fluid underwent a change and became thinner and lighter. Abscesses indicating secondary infection are treated surgically.

Treatment of sinuses. Here local heliotherapy proved to influence favorably the secretion of the sinuses and to facilitate a final closure. The general insulation on the other hand, has much less effect, and acts much more slowly upon the healing of the fistulous tract. In cases with long-standing sinuses often complicated with secondary infection he uses antiseptic medication and flushings with a simple hypertonic salt solution with maintenance of good drainage. When the sinuses under the influence of the sun or spontaneously, show a tendency to close prematurely with retention, the author takes recourse to dilatation with laminaria bougies.

Solieri, some years ago, advocated the covering up of the sinuses under a closed plaster cast, maintaining that in his experience the fistula would close up as well in a plaster-of-Paris cast, especially under the influence of absolute fixation of the joint, and that thereby a protection is offered against secondary infection from the outside. The author found that in several cases of the narrow and tortuous sinuses which produce occasional rises in temperature, the closed plaster-of-Paris apparatus was well tolerated

and proved beneficial. It is certain that one does not lose much by giving up local radiation by the sun. According to the author's experience, it is above all the general radiation which produces the favorable effect, and it can be applied as well in cases in which Solieri's method is used. It seems to him absurd to pretend that a tuberculous hip disease could be cured only by local radiation of the sun, the action of which is admittedly superficial. According to his view, the method of Solieri, if it does not solve the therapeutic problem of open tuberculosis, has the great merit of demonstrating in these open forms the therapeutic value of articular rest, together with protection of the joint from infectious agencies outside. Occasionally surgical intervention is practical on old fistula tracts; those that do not show any tendency to heal are subjected to the surgical removal.

Correction of faulty position. In order to correct the faulty position after the disease has come to clinical arrest, the author applied the angular subtrochanteric osteotomy, according to Comisso, in thirty-one cases. In only one of these did deformity in adduction recur. The technique of Comisso's osteotomy is very similar to that of the bifurcation, the lower fragment being displaced inward toward the acetabulum so that an angulation with formation of a coxa vara occurred. Of the thirty hips subjected to osteotomy, thirteen had healed with bony and seventeen with fibrous ankylosis. The latter, however, offers no difficulty to weight-bearing.

The general treatment. Heliotherapy and climatotherapy:—All patients were subjected to treatment by the sun and climatic influences. So far as the local effect of the sun is concerned, it is noted that it influences favorably the wound infiltrations, the fungoid masses, and the abscesses which are superficially located. The effect is due most likely to the active hyperaemia which it produces and to the sterilization of the exudates. General heliotherapy he considers a most faithful ally in the scheme of treatment for tuberculosis of the hip.

On the other hand, the therapeutic value of the local heliotherapy was inversely proportionate to the depth of the lesion. The author takes issue with the interpretation that a good pigmentation is prognostically a favorable sign. He, as well as Vacchelli, was able to observe repeatedly that the phenomenon of pigmentation is noted in individuals in whom the disease takes a rapid course and who are already suffering from tuberculous cachexia. The beneficial effects of solar treatment are enhanced by the further use of sea baths, both in closed and in open forms of tuberculous disease.

Medicinal treatment. In all patients calcium in the form of calcium carbonate or calcium phosphate was used; also arsenic in combination with iron citrate was given.

Radiographic observations. Of particular interest are the author's radiographic studies. His radiographic series comprise 224 cases. First, referring to negative films in cases of definite osseous tuberculosis of the hip joint, he believes that such instances are much more frequent than is generally believed. Another form which often escapes radiographic diagnosis is the specific synovitis, the presence of which is only indirectly concluded from a certain degree of bone atrophy. More than once the author witnessed a sudden substitution of this atrophic field by a definite picture of bone destruction. Therefore, in the face of atrophy which persists as the only radiological sign during the entire second year of the disease, one must be cautious in interpretation and one must insist upon treatment until reparative changes have made a decided appearance. Another sign of rather early occurrence is the narrowing of the interarticular space, that which the French call "*pincement articulaire*". In his series the author observed it during the second year, in sixty per cent. of the cases. Upon this follows a slow destructive process of the roof or the head. A destructive enlargement of the iliac portion of the acetabulum with migration of the head upward ensues. Among the symptoms of early periods is also to be mentioned the capsular swelling, also the fungous infiltrations and the formation of the abscess casting soft shadows over the hip joint. The presence of such changes must lead us to suspect grave destructive lesions in the bone itself. These destructive lesions are particularly a phenomenon of the second year, and as mentioned, they begin with the picture of intense atrophy; then follow small erosions which

gradually progress. In seventy per cent. of his cases the first destructive sign was located in the roof of the acetabulum. Seventy-nine and four-tenths per cent. of his 224 cases comprising this radiographic study had their initial focus in the iliac portion of the acetabulum; this resulted in an enlargement of the socket and subsequent rising of the head to the upper part of the cavity. Occasionally, however, the head of the femur becomes completely dislocated, so as to rest on the external iliac fossa. This event depends upon the position of the limb and the action of the muscle contractures, as well as upon the destructive changes in the bones themselves. In two per cent. of the cases only, he found the focus situated in the lower half of the acetabulum. The femoral portion, head or neck, was involved in fifty per cent. primarily. The zone of predilection for the head was the upper third. The persistence of sinuses often found its explanation in the presence of small sequestra within the region of the primary focus. There is one barrier to the progress of the primary lesion in the head,—namely, the epiphyseal cartilage. Some stress is laid upon the so called cervico-obturator line of Shenton. This is a line marking the superior border of the obturator foramen, which in its continuation runs exactly in a line with the inferior margin of the femoral head. Shenton's symptom is an interruption of this line due to the rising of the femoral segment upward. This was observed in not less than sixty-nine and two-tenths per cent. of these cases.

The pathological dislocation as an early manifestation of the disease was observed in only one case. This was of a girl of seven years in whom the symptom arose in the first few months of the disease.

On the other hand, as a result of grave destruction of the acetabulm and of the head, late dislocations were observed in six and two-tenths per cent. of the cases. In two per cent., or in five cases, a secondary acetabulm was formed at the outer surface of the os ilii. In four cases a central dislocation of the femoral head with penetration into the pelvic cavity was found. This penetration of the segment into the pelvic cavity may occur from a partial fracture of the acetabulm or it may follow circular erosion of the floor.

In two per cent. of the cases, a certain degree of variety of the femoral head was observed. This, however, was not due to a true inflection of the femoral head but rather to a hyperostosis of its internal surface and of the lower portion of the head, simulating a diminution of the angle between the axes of neck and shaft. One should speak, therefore, rather of a pseudovarism. In one case there existed a high degree of retroversion of the femoral head. Such a deformity might give rise to violent neuralgic symptoms, owing to the vicinity of the crural nerve.

The reparative symptoms in the radiologic picture develop *pari passu* with the clinical improvement. One notices in cases of sinuses a more intense decalcification; calcification of abscess was not infrequently observed in form of dense shadow. In two cases tuberculosis of the hip was observed in congenital dislocations which had not been reduced. The focus in one case was in the acetabulum and in the other in the femoral head. The cases which were clinically cured presented in the radiographic picture the following types of repair:

Complete restitution 13.1%;
Fibrous ankylosis 16.6%;
Osseous ankylosis 13.6%;
Pseudarthrosis with large socket and small head, 15.4%;
Nearthrosis 4.1%.

The high percentage of cures with bony ankylosis found in the radiographic series may possibly be explained by the stimulus offered to the reparative process by the sun and climatic treatment; both were capable of producing powerful defence reaction on the part of the tissue. The solid bone trabeculae which were found to run from the femur to the os ilii represent a high degree of reparatory ability much in excess of that in fibrous ankylosis. Such solid ankylosis was never observed before the eighteenth

year of life, which goes to demonstrate that age also has its influence upon the phenomenon of repair, and that the adult hip represents a greater capacity for osteophytic reconstruction. All of the patients healed with bony ankylosis were from eighteen to thirty years old and eighteen of these cases, which in infancy had healed with fibrous ankylosis, showed later a complete change from the fibrous to the bony ankylosis in adult age, but this never occurred before the eighteenth year of life. Such points are of particular interest, inasmuch as it brings up the question whether it would not be better to suppress completely motion of the hip by a solid bone union and to introduce such operative measures of fusion as are proposed by Albee, Hass, Hibbs, Kappis, Putti, and others. The author is not able to express himself on the value of such operative intervention as it was not carried out in his institute. In five and three-tenths per cent. of his cases osteophytic changes in form of hyperostoses were seen producing small bony spicules and lippings which extended from the roof of the acetabulum toward the head of the femur. All these cases, also, were of adults.

The author believes that a prognostic conclusion can never be drawn from initial findings of tuberculosis of the hip in the x-ray picture. Neither is the radiogram capable of giving definite information in regard to the functional capacity of the hip after healing is complete, with the exception of the case where a complete bony ankylosis had been produced. In all other cases two hips may present identical and characteristic radiographic pictures and one may be entirely movable while the other remains entirely rigid. The question as to whether the radiographic evidence may decide the state of repair is answered by the author, in the sense that while it is not a complete method of determination it is of inestimable value in judging it. Under one condition only complete cure can be definitely recognized;—namely, when dense and regular bone trabeculae are found to unite femur and pelvis into one osseous union. The author has seen more than one development of an abscess, where the hips appeared well recalcified. Even where the process of restitution shows a most homogeneous distribution of lime salts with sharp and dense shadows, it is still hazardous to venture an opinion of complete biological repair; it is necessary that the clinical examination also indicates complete cure before such an inference can be drawn from the x-ray picture.

Results. The total results of the 356 cases of hip disease were as follows:

Cured 47.2%;

Improved 40.5%;

Not cured 4.2%;

Died 8.1%.

The causes of death are classified as follows:

Tuberculous cachexia, meningitis, and miliary tuberculosis constitute the cause of almost eighty per cent. of all deaths. In comparison, Vacchelli in his statistics from the Istituto Rizzoli has a mortality of thirteen and seven-tenths per cent., while Nussbaum, following entirely conservative treatment, has a mortality of thirty-three and nine-tenths per cent. Therefore, the author's results from the viewpoint of mortality were rather exceptionally good.

The details of cure. Perfect gait was observed only in cases which healed with total restitution of function. In cases which had healed with limitation of movement but not in faulty position, the function was more or less slightly impaired. Those healing with even faulty position or with considerable shortening naturally showed considerable impairment of function.

The orthostatic function of the hip was best in cases healed in good position, even with shortening, where the latter appeared well compensated. Non-compensated shortening and flexed or abductory position showed invariably a considerable diminution of functional capacity. The synovial and purely osteitic forms, in general, healed with return of function or, at most, with slight limitation of the articular play, while the osteo-arthritic forms represented in general a considerable functional impairment, which ranged from slight limitation of walk to complete inhibition of the locomotion.

Duration of treatment. In the 168 cured cases the duration of the treatment was extremely variable, ranging from one to eighteen years; the average being about three years of treatment.

Recurrence was comparatively rare; it was observed in eight cases, from two years to ten years after healing.

In consideration of the grave condition which tuberculous disease of the hip represents, the author feels more and more convinced of the necessity of earliest possible treatment. Such treatment must be adequate, uninterrupted, and efficient, from the beginning to the time when complete healing of the disease has been definitely obtained. —*A. Steindler, M.D., Iowa City, Iowa.*

TRAUMATIC IMPACTION FRACTURE OF THE ACETABULUM WITH INTRAPELVIC DISLOCATION OF THE HEAD OF THE FEMUR. Antonio Romani. (Padova): *Chir. d. org. di movimento,* XII, 360, July 1928.

The largest series of cases from the literature presented up to 1922 is that of Cottalorda who reported on 109 cases of which ten were of personal observation. The author had made further bibliographical studies which yielded him 175 observations to which he adds the description of four cases from his own experience. In one case especially, it was interesting to follow the slow and gradual processes of the impaction and the dislocation of the femoral head. This fact would confirm the opinion that the femoral head becomes embodied into the interior of the pelvis only secondarily,—namely, through the action of the pelvic trochanteric muscles. The other cases were not treated by the author; one was simply treated by plaster bandage and left to himself, while another had no adequate treatment up to the time of observation. In the fourth case the radiological examination was not undertaken immediately and the condition was not recognized at the beginning.

In order to clarify the question of the mechanism in the production of these lesions the author has undertaken experiments on the cadaver, twenty-two experiments in all. Only once was he able to produce the central dislocation of the femur by blow upon the trochanter, and that was in the case when the femur was placed in extension and inward rotation and midway between abduction and adduction.

Relative to the etiology and pathogenesis of this lesion, it is being assumed that the femoral neck offers an abnormal resistance to a fracture, which would be the usual result of the injury. Amante, in 1909, carrying out sixty experiments on the cadaver, was likewise able in two cases only to obtain a central dislocation of the femur and Cottalorda, from his experiments, drew the conclusion that these fractures are experimentally obtainable only in lateral position and with the lower limb in extension, inward rotation, and in mid-position between abduction and adduction, coming to the same results as the author. But we note in the literature that the mechanisms reported do not always coincide with these experimental conditions. A typical case is that reported by Kronlein. Here, a central dislocation of the femoral head on both sides was observed in a patient who had fallen violently upon both feet. According to Delannoy there are three types of traumatism: (1) fall upon the great trochanter; (2) fall upon the feet; (3) fall upon the shoulders. Froelich also divides the mechanism of injury into three classes. In the first, which comprises the great majority of cases, the fracture of the acetabulum and the impaction of the head into the small pelvis occurs simultaneously; in the second group, which involves only a small number of cases, the impaction of the femoral head does not occur immediately, but follows attempt at walking; in the third group the penetration of the head into the pelvis occurs only slowly and is due to a process of softening of the bones forming the acetabular cavity.

In the cases which came under the observation of the author he was able to note a gradual progress of the femoral head a few hours after the trauma and accompanied by an increasing flattening of the trochanteric region. He also could establish the fact, in another case, that the impaction of the femoral head occurred very slowly and was due

to a decalcification of the pelvic bone. Considering the direction of the force of the muscle groups which come into consideration, it appears very likely that the flexor muscles, especially the iliopsoas, are the ones which play the most important part in the upward ascent of the limb.

As to the age incidence of this injury, Henschen states that the majority of cases occur between twenty-one and thirty years. The author's statistics show also that the male sex is involved seven times more often than the female sex (118 men and 17 women).

Pathological anatomy. According to Henschen two anatomical types exist. To the first belongs the central dislocation proper in which the femoral head is jammed against the floor of the acetabulum and buries itself in the pelvis. To the second group belong the cases in which the dislocation is excentric. If the hip, at the moment of the trauma, is in adduction and in external rotation and flexion, the femoral head is jammed against the anterosuperior quadrant of the acetabular cavity and buries itself between the anterior-inferior iliac spine and the eminentia ileopectinea. Here we have, then, a dislocation upward and forward. If, however, the thigh is in abduction and internal rotation and flexion, then the femoral head is jammed against the anterior and inferior quadrant of the acetabular fossa; the dislocation occurs downward and forward. Froelich divides the pathological forms of this dislocation into three types: (1) impaction into the floor of the acetabular cavity, in which the floor is detached into the pelvis as a crystal would be from the dial of a watch; (2) the floor of the acetabulum is detached in triangular form and its base is directed toward the acetabulum, the apex representing the horizontal branch of the os pubis; (3) there is a fracture of the floor of the acetabulum, a triangular fragment with its base at the posterior inferior quadrant.

However, in the great majority of cases a classification from these pathological points of view becomes very difficult. Probably the simplest classification is that of Delannoy who takes into consideration principally the degree of detachment of the femoral head in the direction of the lesser pelvis. Aside from the lesion of the skeleton, one must also study the injuries to the soft parts. Rarely, lesions of the round ligaments were observed, or those of the capsule. On the other hand, injuries of the muscles, especially of the iliopsoas and of the internal obturator are not uncommon. Of nerve injuries one sees those of the obturator nerve, produced by osseous fragments or callus formation; also injuries to the femoral nerve and to the sciatic nerve, which produce violent neuralgias in the anterior and posterior regions of the thighs, have been repeatedly mentioned. Of vascular lesions there were noted injuries of the external iliac vein, of the gluteal artery, and of the mesenteric vessels. Among the less common visceral lesions are to be mentioned rupture of the large intestine by osseous fragments; rupture of the urethra and bladder.

Symptoms and Diagnosis. The clinical picture is mainly characterized by a variable degree of shortening, and generally by the inward rotation of the limb. To this Boekel has added another symptom;—namely, the inward rotation of the foot. It is easily corrected and, if once corrected, it maintains itself continuously in normal position (the so called symptom of Boekel). The trochanteric region appears flattened and the trochanter is visibly approached to the median line. Besides, the trochanter rises upward, especially in the excentric form.

A notable symptom is also the pain elicited by pressure upon the trochanter and sometimes also by percussion of the iliac crest. There are also pressure pains in the fossa iliaca interna and in the entire lower quadrant of the abdomen. Such palpation permits, in cases of true dislocation often the feeling of the round, dislocated head. The abdomen often shows meteorism, possibly due to compression of the penetrating osseous masses in the small pelvis and to the hemetoma which is formed around the region of the fracture. There is also a symptom of urinary retention, possibly also dependent upon the above named hematoma.

One of the principal objective symptoms, which was described as early as 1835 by Earle, is revealed by rectal examination. Here one finds acute tenderness and sensibility; often the roughness of the osseous fragments can be felt and occasionally crepita-

tion can be noted. In cases of dislocation, the smooth and regular surface of the femoral head, which moves together with the movement of the limb, can be made out. Such examinations together with the radiographic findings constitute a principal and most positive point in the diagnosis. Radiological examination, of course, is indispensable. In some cases the picture shows complete peeling off of the entire acetabular cavity. In others a progressive dislocation due to muscle action or a late dislocation due to weight-bearing can be made out in the x-rays. Often one sees a reduction in the volume of the femoral head, due to atrophy or decalcification, and not infrequently definite symptoms of a secondary osteo-arthritis appear.

Prognosis. The prognosis as to life is rather severe. Among 135 observations twenty-one ended fatally. The causes of such an event are shock or vascular lesions, often lesions of the intestines, of the bladder, or of the ureter.

As far as the prognosis relative to cure is concerned, it must be mentioned that functional impairment with diminution of working capacity is always to be expected. The degree of disability varies from fifteen to fifty per cent. According to Cottalorda the average disability is thirty to forty per cent.; while Montanari calculates the figures from thirty-eight to sixty per cent.

In the collected statistics of the author twenty-nine cases appeared completely healed and in seventy-seven cases healing occurred with functional impairment; and twenty-one cases died.

Treatment. It must be recognized that the success of the treatment is the surer, the earlier the diagnosis is made. If the femoral head is impacted into the pelvis but not hooked between the bony frame, simple traction, in longitudinal direction and slight adduction, or in other positions according to the case, will prove sufficient to effect reduction of the dislocation. When this is accomplished,—and the fact can be ascertained by measuring, rectal examination, and x-ray pictures,—continuous traction is applied, which is left in place for two weeks and then a plaster cast is made. The cast is left for about one month, after which the patient is treated with massage and mobilization. Whitman mobilizes the limb in strong abduction. This has the advantage that the femoral head becomes separated from the floor of the acetabulum, thanks to the fulcrum which the greater trochanter finds in the upper border of the acetabular cavity.

In cases which cannot be reduced by simple longitudinal traction, it will be convenient to add also traction in transverse or lateral direction. Delitala practised an incision of the skin over the greater trochanter and by insertion of strong ice tongs a powerful lateral traction could be obtained.

In those cases in which reduction failed and which had healed with ankylosis in faulty position, subtrochanteric osteotomy is to be advised. The principal points in the treatment of central dislocation of the femur is that it be recognized at the earliest possible time, and be adequately treated. Under these conditions the prognosis as to function is comparatively favorable, notwithstanding the poor results which heretofore have been published.—*A. Steindler, M.D., Iowa City, Iowa.*

FRACTURES OF THE CLAVICLE. A SIMPLE FIXATION DRESSING, WITH RESULTS ATTAINED IN NINETY-TWO CASES. H. Earle Conwell. *J. Am. Med. Assn.*, XC, 838, Mar. 17, 1928.

The author presents in photographic illustration a simple and apparently efficient manner of strapping the shoulder to maintain an upward and outward position in fractures of the clavicle. Results were good in seventy-five cases, fair in twelve, and poor in five.

With complicating injury at the shoulder joint, the arm is splinted in traction at a position of ninety degrees abduction and outward rotation. Traction should also be used when there is marked overlapping in the clavicle and will correct most of the deformity.

Good function may be expected without perfect anatomical replacement. Open reductions are rarely indicated.—*W. B. Carrell, M.D., Dallas, Texas.*

O-Iodoxybenzoic Acid in the Treatment of Infectious Arthritis. Harry C. Stein and Norman Taube. *J. Am. Med. Assn.*, XC, 1608, May 19, 1928.

The authors made a careful study of 100 cases of arthritis, various types, but all ambulatory, and two cases of rheumatic fever. The preparation used was amiodoxyl benzoate (Abbott). Technique of administration was identical to that used by Young and Youmans but with a different result. The two cases of acute rheumatic fever were made worse. Thirty-one of the ambulatory cases received temporary relief, but returned later with the same or exaggerated symptoms. Sixty-nine were not relieved. There was no reduction in swelling, no increase in joint motion, and no relief from pain. The results on the whole were unsatisfactory and the treatment discontinued.—*W. B. Carrell, M.D., Dallas, Texas.*

Pseudarthrosis of the Tibia in Young Children. Richard B. Dillehunt and John Le Cocq. *J. Am. Med. Assn.*, XC, 1615, May 19, 1928.

Firm union was obtained in the case of a boy two and one-half years old who had pseudarthrosis of two years' duration. The non-union was not from a fracture, but from loss of bone by resection incident to treatment of an acute osteomyelitis.

At operation the bone ends were separated by a fibrous mass containing a bursa-like cavity filled with fluid. The fibrous tissue was dissected out, and the bone ends cut back to vital bone. Care was exercised in saving the periosteum intact over the remaining bone, and the two ends contacted without tension. Union followed.

The detail of interest, and which may have a bearing on the difficulty encountered in such cases, is the preservation of the blood supply from the periosteum around the bone ends.—*W. B. Carrell, M.D., Dallas, Texas.*

Köhler's Disease of the Tarsal Scaphoid Bone. Morton Seldowitz and Leo Zimtbaum. *J. Am. Med. Assn.*, XC, 1617, May 19, 1928.

The authors report a case of Köhler's disease in a boy of six, with recovery in four weeks following anti-rachitic treatment. The boy was observed six weeks prior to starting treatment and two blood studies gave a combined calcium and phosphorus product of forty and thirty-six respectively, which indicate a rachitic state. After treatment with ultraviolet ray and cod liver oil the combined product came up to normal fifty, and the x-ray showed increased calcium deposit in the scaphoid. Recovery was permanent.—*W. B. Carrell, M.D., Dallas, Texas.*

Local Anaesthesia in the Reduction of Fractures of the Lower Forearm. Carl O. Rice. *J. Am. Med. Assn.*, XC, 1768, June 2, 1928.

Since 1885 local anaesthesia has been successfully used by various surgeons, in the treatment of fractures, but the method has not received popular approval. The author reports cases illustrating the types of fracture selected and has used the technique during the past year in more than fifty cases.

The fracture site is infiltrated with fifteen to sixty cubic centimeters of one per cent. procaine hydrochloride solution to which may be added one drop of epinephrine per dram of solution and thirty minutes allowed for anaesthesia. The solution is introduced to infiltrate the periostial tissue and the bone ends, and from pressure the superjacent structures. Manipulation was painless and no instance of infection reported.

Contraindications are compound fractures, a recent infection, and when procaine has been recently used in the same area.

The advantages are simplicity, elimination of a general anaesthetic and the opportunity to make several redressments without discomfort to the patient.—*W. B. Carrell, M.D., Dallas, Texas.*

FRACTURES OF LUMBAR VERTEBRAE DUE TO HYPEREXTENSION AND EXTREME MUSCULAR ACTION. Clifford Lee Wilmoth. *J. Am. Med. Assn.*, XCI, 6, July 7, 1928.

Hyperflexion fractures producing compression of the vertebral bodies are quite common and surgeons are looking for them. The chipping of a small piece of bone from the anterior margin of a vertebra by hyperextension of the spine, or the fracture of a transverse process by extension and torsion, are frequently overlooked because the accident appears so trivial. A diagnosis of back strain is usually made. The history of severe localized pain with sharp tenderness at a lumbar process, immediately following a moderate or severe hyperextension twist in the back should suggest this condition. X-rays, anteroposterior and lateral, will confirm or disprove it.

Sixteen cases are reported and prognosis is good following suitable treatment. Early physical therapy measures of deep massage and motion lead to increased tenderness and prolonged convalescence. Complete rest, as in other fractures about the spine, is required for firm union of the fractures.—*W. B. Carrell, M.D., Dallas, Texas.*

PROTECTIVE ACTION OF CONVALESCENT POLIOMYELITIS SERUM. Simon Flexner and Fred W. Stewart. *J. Am. Med. Assn.*, XCI, 383, Aug. 11, 1928.

The use of convalescent serum in the early treatment of poliomyelitis has proven beneficial in experimental and clinical cases. The intact choroid plexus and meninges exclude immune serum from passing from the blood to the spinal fluid, but when these structures are damaged by inflammation or otherwise, the serum passes through. Experiments have shown that direct inoculation of the brain in monkeys will not produce poliomyelitis, if immune serum is given intravenously about twenty-four hours previous to inoculation.

The period of protection has not been determined, but experiments suggest the advisability of giving children exposed in an outbreak of poliomyelitis ten cubic centimeters of convalescent serum, older ones, twenty cubic centimeters, subcutaneously, and repeating in four to six weeks if conditions warrant.

Further details of the experimental work will be published later.—*W. B. Carrell, M.D., Dallas, Texas.*

PREPARALYTIC POLIOMYELITIS. OBSERVATIONS IN ONE HUNDRED AND SIX CASES IN WHICH CONVALESCENT SERUM WAS USED. W. Lloyd Aycock and Eliot H. Luther. *J. Am. Med. Assn.*, XCI, 387, Aug. 11, 1928.

A consecutive series of 106 preparalytic cases formed the basis for the study and comparative tables which are exhibited to show the mortality, extent and degree of muscle involvment with treated and untreated cases.

Emphasis is given to diagnosis in this stage, and subsequent paralysis proved conclusively that attention to signs of meningeal irritation and a spinal fluid examination should enable a doctor to make a positive diagnosis immediately after the onset of symptoms.

The author's report shows an exhaustive investigation of the actual extent of recovery which cannot be adequately abstracted, but the work shows that: those having convalescing serum during the preparalytic stage had a lower mortality rate, a lower average of total paralysis, and a relatively smaller percentage of those cases having the severe grades of muscle damage.—*W. B. Carrell, M.D., Dallas, Texas.*

OSTEOSYNTHESIS IN POTT'S DISEASE. M. Lauwers. *Jour. de Chir.* XXXI, 641, 1928.

The author gives a brief review of the physiology of the spine and states that tuberculous embolisms are stopped there more easily because the arteries are terminal. In Pott's disease two conditions interfere with healing,—the destruction by the tuberculous process and the mechanic influence of compression. The compression is determined by the weight of the next column above, as well as by the muscular contractures.

As a result of the cupping of the anterior column the vertebral arcs are drawn near together. In the cervical and lumbar regions they come in contact with each other. In the dorsal region, on the contrary, the cupping of the plates is hindered by the spinous apophyses which normally cover each other.

The evolution of Pott's disease varies with age. In a child it can be cured almost always by the classic treatment, and destructive action of the tuberculous process is regularly stopped under the effect of general treatment. In cervical and lumbar Pott's disease, the joining of the plates leads to ankylosis and constitutes a kind of natural osteosynthesis. In the dorsal region, on the contrary, recovery may be obtained by bony consolidation of the vertebral body. Bony reparation is the rule.

In the adult, the seat of the tuberculous disease is practically never restored. It is necessary to take account of this tendency in the treatment and to resort to osteosynthesis to assure the ankylosis of the posterior column and stop the tuberculous process. The different methods of osteosynthesis are of three fundamental types: that of Hibbs, that of Albee, and that of Halstead.

Hibbs realizes the bony fusion of the apophyses and the laminae by unsheathing the laminae and breaking down the spinous apophyses, previously sectioned at their base, one on the other.

Albee fuses the spinous apophyses by placing a thin graft in the reduplication of the apophyses previously split.

In the procedure of Halstead the bony fusion of the vertebral arcs is obtained by introducing a large tibial graft in the slit obtained by sawing through the base of the spinous apophyses.

The operations for ankylosis have an unequaled value in the treatment of Pott's disease. In simple Pott's disease manifested by pain, muscular contractures, and cold abscesses, the three processes are applicable. Only the operations of Albee and Halstead are applicable to the gibbosities and the lateral inclinations.

The process of Halstead presents certain appreciable advantages in the treatment of Pott's disease: the fixation of the spine is solid; the graft is strong; the surface of contact between the spine and the graft is large; and above all the graft is subjected to a slight tension. Halstead's method of osteosynthesis most nearly approaches natural osteosynthesis by synostosis of the laminae, because the graft is placed in contact with the vertebral arcs.

The first operation consists in the preparation of the slit which must include the diseased vertebrae and two normal vertebrae above and below the area of disease.

Finally the bed of the graft is prepared by sectioning the spinous apophyses at their base. The section is begun with the aid of a flexible saw brought flat in the costovertebral groove and finished with the gouge. The second operation consists in taking the graft from the internal side of the tibia, and the third consists in putting the graft in place.—*J. A. Key, M.D., St. Louis, Mo.*

DIAGNOSIS AND TREATMENT OF FRACTURE-DISLOCATIONS OF THE SHOULDER. P. Gerard-Marchant. *Jour. de Chir.*, XXXI, 659, 1928.

Symptomatically the cases may be divided into four groups: (1) where signs of luxation and fracture are superimposed, the diagnosis is evident; (2) where the signs of luxation predominate, but where the abnormal character of certain of them make one think it a double lesion; (3) where signs of luxation and fracture are reduced to the minimum; it is then necessary to suspect their coexistence by principle; (4) where the signs of fracture dominate; here again, it is necessary to think systematically of possible displacement of the head.

In all difficult cases radiography is a great aid. Treatment: (1) Old or classic method, of interest only historically; (2) Mobilization: The principle is to abandon the dislocated fragment in mobilizing, to avoid ankylosis. In brief, it is a method the results of which are faithless, but more favorable when applied early, continued for a long time,

practised for dislocations with fracture of the surgical neck and directed to old subjects. (3) Reduction: The method consists in first reducing the dislocation and then consolidating the fracture. In fractures of the surgical neck, reduction succeeded in twenty out of 100 cases, but in fractures of the anatomical neck, reduction was obtained in eleven out of 102 cases. Reduction obtained, gives a complete functional recovery in about half of the cases. (4) Resection: In early resection the results as a whole are very imperfect. After fifty years of age the results are clearly less favorable. In late resection, in fifteen cases of dislocation with fracture of the anatomical neck, seven showed definite improvement. In those of the surgical neck there was also some improvement Neither chondroplastic nor implanation operations have given very good results. (5)Reposition: Observation has shown that it succeeded about two out of three times. There are two principal manoeuvers: the mobilization of the head and then its replacement in the cavity. The reduction of the fracture is generally easy, the real problem is the retention. Early intervention seems to play a very important rôle and most of the favorable results were treated before the fifteenth day.

The author feels that the choice of methods lies beween resection and reposition, and of the two he considers reposition superior. In fractures of the surgical neck, resection is too extensive; and in fractures of the anatomical neck, one fears from resection an insufficient vascularization and a cephalic necrosis. Whatever the method employed, its results will be better if one follows an appropriate after-treatment. Immobilization is in abduction and is short, not exceeding twelve or fifteen days. Mechanotherapy, massage, and electricity complete the therapeutics.—*J. A. Key, M.D., St. Louis, Mo.*

Changes of the Hip Joint Following the Reduction of so called Congenital Dislocation of the Hip Joint. Waichiro Matsuura (Igakuschi), Assistant to Professor Takagi, Orthopaedic Department of Tokyo Imperial University. *Proceedings of the Japanese Orthopaedic Society*, Vol. II, Pt. I, 1927.

Since 1906 we have examined 210 patients, by means of radiographs, after recovery from congenital dislocation of the hip joint. They were treated by non-operative methods. Some of the cases were traced, following up the progress of the condition for eighteen years after the reduction was made, and they were examined, radiographs being taken every two to three months during the first year after the replacement of the hip joint.

An observation was made of the radiographic work systematically, concerning the hip joint changes, studying 112 cases the radiographs of which were perfectly taken through the mid-line anteroposteriorly, after these cases were considered to be anatomically cured. The important measurements of the radiographs were taken to explain the construction of the hip, comparing the affected side with the so called normal side, and, in the case of adults, comparing the affected side with the normal adult hip according to Professor Takagi's statistics.

Following the observation of the author concerning the form of the acetabulum, it was proved that Ludloff's "Gleitfurche" (sliding groove) had disappeared, being filled in by new formation of bone in a year after the dislocated hip joint was reduced. It was further proved that the contour of the acetabulum was improved, and a slight hazy irregular shadow had been formed in those cases which were examined a few years after recovery. The measurement of the acetabulum shows that it develops less inferiorly but more laterally. Also the angle, which is measured through Wollenberg's Y, is larger than that in the normal side in almost every case.

The size of the osseous part of the femoral head was determined by careful measurement, and it was found that there was no difference in curvature of the articular surface of the head of the femur from that of the normal side, though the head is usually flat. In numerous cases in which the dislocation was reduced before three years of age, the head appeared almost the same as the normal side.

The author has written in detail about the atrophy of the osseous tissue of the femur. This was not observed in any case which was examined later than seven years after the

reduction. But there was shown to be an increase of lime deposit in the head during the immobilization treatment period, and it was also seen that there was a peculiar double contour of the head in the recovered cases within three years.

Important measurements were made to explain the relation between the acetabulum and the head of the femur and make clear what is the position and relation between the acetabulum and the head of femur.—*Y. Tashiro, M.D., Tokyo, Japan.*

LARGE FLUCTUATING ABSCESS FROM SUBOCCIPITAL DISEASE. M. Santoro. *Radiol. Med.*, XIV, 564, July 1927.

The article illustrates a case regarding a patient with a large tumefaction of the anterior and lateral regions of the neck or, more precisely, the two supraclavicular fossae. Notwithstanding the slight clinical evidence, radiographic examination revealed the characteristic lesions of a tuberculous spondylitis of the cervical vertebrae.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

A PARTICULAR TRAUMATIC LESION OF BOTH RADIOCARPAL ARTICULATIONS. D. Tartagli. *Radiol. Med.*, XIV, 569, July 1927.

The author describes a unique case of palmar luxation of the hand or, more precisely, anterior luxation of the semilunar and scaphoid occurring bilaterally in the same patient simultaneously. The mechanism was that of a hyperextension of both wrists. He illustrates in detail this very rare observation and discusses the pathogenic mechanism, reporting for that purpose several experiments made in order to explain the pathological picture.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

DETACHMENTS OF THE EPIPHYSES OF THE ELBOW FROM A ROENTGENOLOGICAL POINT OF VIEW. L. M. Asti. *Radiol. Med.*, XIV, 625, Aug. 1927.

The author first describes the manner and order of appearance of the nuclei of the bony extremities which form the elbow, insisting upon the importance of an exact technique. He believes nevertheless that the projections that deform the roentgenological picture of the nuclei cannot be causes of error, since, when the error of technique is such as to alter the relations of the nuclei with the corresponding epiphysis, there will also exist such a deformity of the bony parts as to place the reader on his guard. If the error of technique is not marked, it will not modify the relation between the nuclei and the corresponding parts. He proceeds then to consider separately the various detachments, *viz.* the detachment of the condylotrochlear block, the detachment of the external condyle, the detachment of the epicondyle, the detachment of the trochlea, that of the epitrochlea of the olecranon and that of the nucleus of the radial head. Of almost all of these varieties he gives examples, basing his observation upon 800 cases of trauma of the elbow. The difficulties that may be presented in the interpretation of some roentgenograms may be great. The author believes that cases of detachment are to be considered as rare and gives the roentgenological data for making the diagnosis of the condition.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

CONTRIBUTION TO THE ROENTGENOLOGICAL DIAGNOSIS OF LESIONS OF THE SPINAL CORD WITH LIPIODOL. G. Barbacci. *Radiol. Med.*, XIV, 663, Aug. 1927.

The author reports the results he has obtained in intraspinal research with lipiodol in four cases, *viz.* epidural tumor, spondylitis, vertebral fracture, and gumma of the cauda equina. In all the cases the examination has been satisfactory, as it has established with exactness the point of block of the opaque column in correspondence with the point of narrowing of the meningeal canal. He advises lumbar injection of one to two cubic

centimeters of dense lipiodol and placing the patient immediately afterward in Trendelenburg's position. In conclusion, the author states that this method can be of great service, notwithstanding its defects; that it should be employed only after an accurate clinical and neurological examination; and that it should be used before any surgical intervention is made on the spinal cord.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

CHRONIC PRIMARY OSTEOMYELITIS OR TUMOR METASTASIS. R. Feci. *Radiol. Med.*, XIV, 768, Sept. 1927.

The author describes a case of bone metastasis from a benign tumor (papilloma) of the renal pelvis diagnosed at the operating table and also histologically. After some months the manifestations in the bones were the only evidences that could be verified clinically, which explains why, when the patient presented clinical symptoms of an inflammatory process, the diagnosis was long in error. A roentgenological examination of the lungs, before intervening on the skeleton, revealed the existence of numerous metastatic foci disseminated throughout the lung tree. Thus the nature of the bone lesion was established. The author concludes, stressing the importance that a roentgenological search may assume in the diagnosis in retrospect of the malignity of a tumor that by its clinical course, by the biopsy at operation, and by the histological examination, was held to be benign.—*Vittorio Putti, M.D., Bologna, Italy.* (*Translation by Murray S. Danforth, M.D., Providence, R. I.*)

A PORTABLE FRAME FOR THE SUSPENSION AND TRACTION OF FRACTURES OF THE LOWER EXTREMITY. Guy A. Caldwell. *Southern Med. J.*, XXI, 438, June 1928.

This consists of a gas pipe Bradford frame to which is attached cot springs and covered with a light mattress. There is an adjustable overhead gas pipe bar with an adjustable and moveable suspension piece similar to the one used on the usual Balkan frame. A modified Thomas splint is used and fixed traction applied by means of ice tongs or Steinmann pin attached to a scale indicating the amount of traction, this in turn being attached to a turn-buckle which is fixed to the end of the Thomas splint. There is an adjustable foot piece to prevent toe drop. This is a very compact, convenient, and accurate method of treating fractures. The advantages are that the patient can be moved about to the porch, to the x-ray room, and if necessary be transported considerable distances, without disturbing the fracture or changing the traction. The cost of the frame and mattress is about $35.00. The cost of the modified Thomas splint and Steinmann pin is about $30.00.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

COMPOUND FRACTURES. Muir Bradburn. *South. Med. J.*, XXI, 446, June 1928.

The usual method of cleaning up is used. He does a modified debridement if case is seen in the first eight to ten hours. Most cases are treated by skeletal traction and suspension. He uses Lane's plates or other means of internal fixation if indicated. In a group of fifty cases of compound fractures, five had gas bacillus infection. In two of these amputations were done. The author objects to any packs or drains being put in these wounds.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

GENU VARUM AND GENU VALGUM INFANTUM. M. Boehm. *Ztschr. f. orthop. Chir.*, XLIX, 321, 1928.

There is no doubt that many cases of genu varum or genu valgum are not caused by rickets. However, various theories which have been worked out to explain these frequent deformities have not been satisfactory to Dr. Boehm who with his well known industry and skill has carefully studied this problem. His studies have led him to the conclusion that the non-rachitic genu varum and valgum represent a regressive rather

than a progressive variation of the development of the skeleton of the lower extremities. The normal phylogenetic development shows very distinct declinations of a more or less degenerative character. Static and mechanic forces, weight-bearing and transformation, heretofore considered to be of sole or main value in the development of lateral deformations of the legs, are not of such importance in regard to the primary development, but act only as a secondary force after the natural varying development has induced the characteristic declination. The human leg of the new-born lies in a position of flexion, lateral declination, and outward rotation of the knee joint. Postnatal development during the first five years, as Boehm has observed on many children as well as specimens of cadavers, shows a disappearance of the flexion, a slight medial declination, and a slight inward rotation of the knee. In certain cases, however, variation of the normal development takes place in a progressive rather than a regressive sense, leading eventually to the formation of a genu valgum rather than a genu varum.—*C. Hermann Bucholz, M.D., Halle, Germany.*

Rare Cases of Rupture of the Biceps Tendon. V. Schmieden (Frankfurt). *Zentralbl. f. Chir.* LV, 940, 1928.

Ruptures of the biceps tendon generally occur at the long head and with tendons which are pathologically degenerated. Schmieden has seen in such cases good functional results with suture of the long head at the short head. In one case of rupture of the lower tendon of an athlete, he has sutured that tendon at the brachial muscle, because it was in the arm of a very muscular man and the anatomical relations are very inopportune to the repair at the radial tubercle. At the examination five months after the operation, the flexing function of the biceps was decreased but five per cent. The supinating function was reduced forty per cent., but the supination of the forearm was sufficiently compensated by the much hypertrophied brachioradial muscle.—*C. Hermann Bucholz, M.D., Halle, Germany.*

Operation for the Habitual Dislocation of the Shoulder Joint. Kirschner (Tuebingen). *Zentralbl. f. Chir.*, LV, 946, 1928.

Kirschner discusses Hoffmann's operative method for the repair of the habitual dislocation of the shoulder, which consists in slinging a wire around the humerus and fastening it to the acromion. Kirschner points out that Hoffmann's method is but a poor modification of his own method, consisting in slinging a fascial ligament around the head of the humerus without opening the joint. Kirschner has operated on thirteen cases and in only one case recurrence has taken place. Most of these cases were operated on many years ago. Lately Kirschner has pulled the fascial strip through a bone channel just below the head in sagittal direction. He thinks his method is simpler and less dangerous than those methods which open the joint. An absolute guaranty cannot be given by any method, in regard to the avoiding of recurrences.—*C. Hermann Bucholz, M.D., Halle, Germany.*

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